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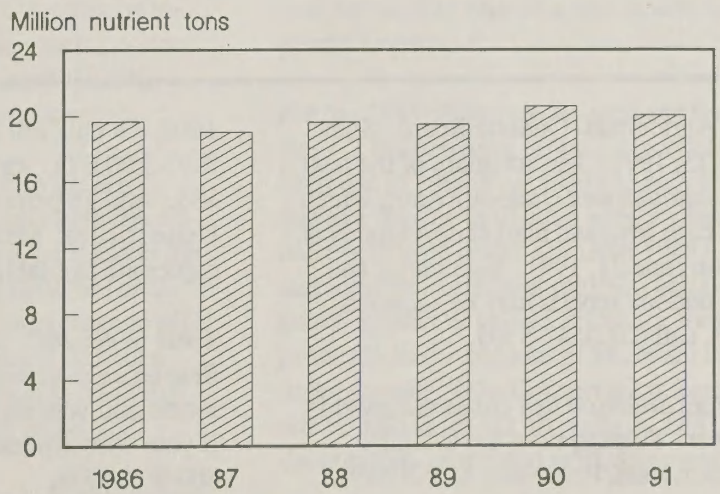
Situation and Outllook Report

Fertilizer Consumption to Slip from 5-year High



1991 forecast.

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Summary

During the 1990/91 fertilizer year, plant nutrient use in the United States is expected to decline 3 percent from the previous year to 20 million nutrient tons. Nitrogen use is forecast at 10.7 million tons, phosphate at 4.2 million, and potash 5.1 million. Projected changes in planted acreage and crop mix combined with stable application rates are the principal reasons for the decline. A decline in wheat acreage is expected to more than offset a projected increase in corn acreage. Fertilizer supplies, though higher priced, will be adequate for anticipated use.

Tightening world fertilizer supplies and concern over the Persian Gulf have put upward pressure on prices. U.S. spring fertilizer prices will likely be 5 to 9 percent higher than last year.

World fertilizer production and use are expected to increase most in developing countries and the centrally planned economies of Asia. Projected regional fertilizer shares indicate a continued shift in production and use from the developed to the developing countries. World fertilizer trade patterns will continue, with Canada, Eastern Europe, and the USSR supplying nitrogen fertilizer to the United States, Western Europe, and Asia.

Pesticide use on the 10 major field crops in 1991 is projected at 481 million pounds active ingredient (a.i.), up 16 million pounds from 1990. Herbicide use is expected to rise 12.2 million pounds due to an estimated 4-percent expansion in corn acreage and a 1-percent rise for soybeans. Insecticide use is forecast up 3.9 million pounds in 1991, largely on the strength of a projected 18-percent increase in planted cotton acreage. Fungicide use is expected to remain stable, with peanut production accounting for the highest poundage.

Production methods for the major field crops in the last 3 years indicate a slight increase in the use of conservation tillage systems. For the most part, this reflects a decrease in the use of the moldboard plow. The proportion of highly erodible land utilized for crop production under conventional tillage methods decreased slightly in 1990 from the previous year, and should continue to decline over the next few years, as farmers implement approved conservation plans.

Energy supply and price expectations for the U.S. agriculture sector reflect world crude oil market conditions. Though world crude oil supplies are currently judged to be adequate, the price in 1991 is expected to increase moderately to sharply above the 1990 average of $22 per barrel, depending on developments in the Persian Gulf. Farm prices for diesel fuel, gasoline, liquefied petroleum gas, and electricity will rise accordingly.

Farm energy expenses in 1990 likely increased slightly to $7.2 billion. The increase was due to a modest gain in cropland planted and harvested and a slight increase in the number of acres irrigated, combined with higher refined petroleum product prices late in the year. Farm energy expenses accounted for an estimated 6.2 percent of 1990 cash production expenses.

Unit sales of tractors and other farm machinery rose in 1990, continuing a general trend begun in 1987 as farmers replaced aging equipment. After weakening in August, September, and October, farm machinery sales finished the year with renewed strength. Sales increased 23 percent for four-wheel-drive tractors in 1990, and 15 percent for combines. Four-wheel-drive tractors accounted for 8 percent of farm tractors sold in 1990, continuing an upward trend from 1987 when they were just 3 percent of sales.

Sales of tractors and all other farm machinery are forecast to increase in 1991 by an average of 4 percent. Projections of increases in demand for 1991 are complicated by the unstable situation in the Persian Gulf and the recent economic downturn. Factors expected to stimulate demand include reduced debt and interest rates, as well as increased commodity exports, net incomes, and asset values. The value of 1990 farm machinery exports exceeded imports by $700 million, the second year in a row in which U.S. exports surpassed imports.

For the 1989/90 crop year, seed use for the eight major crops was 6.2 million tons, down 2 percent from the previous year. Seed use in 1990/91 is likely to be 5 percent below 1989/90 due to a decline in planted winter wheat acreage. In 1990, most field seed prices fell from 1988 and 1989 levels, as normal weather conditions returned and seed supplies were ample to meet demand. Prices for forage seeds also were generally lower because of abundant supplies and a decline in the growth of the Conservation Reserve Program. The prices-paid index for all seeds in 1990, at 165, was close to the previous year's and is likely to remain flat in 1991.

The net seed trade surplus surged 46 percent to $309 million in the first 9 months of 1990 compared with the same period a year earlier. The increase primarily reflects gains in corn, vegetable, and forage seed exports.

Fertilizer

Consumption

Plant nutrient use in the United States is forecast at 20.0 million nutrient tons during fertilizer year 1990/91 (July 1-June 30), down 3 percent from the 20.6 million used in 1989/90. For nitrogen, use is forecast at 10.7 million tons, 4.2 million for phosphate, and 5.1 million for potash. During 1989/90, farmers used 11.1 million tons of nitrogen, 4.3 million of phosphate, and 5.2 million of potash.

Fertilizer use in 1990/91 is expected to decline. Although planted area of corn, the major fertilizer-using crop, is expected to increase, planted area for wheat, the second most important fertilizer-using crop, is expected to decline 13 percent (table 1). Gains in planted area are also expected for soybeans, cotton, and rice, but small decreases are anticipated for sorghum, barley, and oats.

Fertilizer application rates on corn, cotton, soybeans, and wheat acreage are expected to remain near the levels of 1990. During that year, application rates for these crops rebounded somewhat from the wet soil conditions that hampered spring 1989 fertilizer applications in some areas.

Spring 1991 fertilizer prices will likely be higher than a year earlier since tightening supplies and the crisis in the Persian Gulf have put upward pressure on prices. Wholesale fertilizer prices have risen over 30 percent for most products since August 1990.

Exports of fertilizer materials during 1990/91 are projected to rise from a year earlier due to reduced domestic demand and increased demand in developing countries. Overall, nitrogen exports will likely climb 2 percent (table 2). Phosphate exports should remain close to last year's levels if diammonium phosphate shipments to Asia stay weak. Potash exports are expected to increase over last year by about 15 percent.

Table 1--Acreage assumptions for 1991 input use forecast

Crop	1990 actual	1991 forecast
	Million planted acres	
Wheat	77.3	66.0 - 69.0
Feed grains	103.9	103.0 - 109.0
Corn	74.5	75.0 - 79.0
Other 1/	29.4	28.0 - 30.0
Soybeans	57.7	58.0 - 61.0
Cotton (all types)	12.3	14.0 - 15.0
Rice	2.9	2.9 - 3.3

1/ Sorghum, barley, and oats.

Supplies

Domestic supplies of nitrogen fertilizer should be adequate to meet 1991 crop needs as production and imports increase in anticipation of higher prices. During the second half of the 1989/90 fertilizer year, higher imports partially offset reduced domestic production and created excess supplies which placed downward pressure on domestic prices. Then in the first half of the 1990/91 year, higher world prices resulting from reduced production in Central and Eastern Europe and the crisis in the Persian Gulf tightened supplies, and in general strengthened the U.S. market. The forecast is for increased domestic production and imports of nitrogen to exceed domestic demand. Domestic phosphate and potash supplies will be ample because of increased domestic production supplemented by potash imports from Canada.

Table 2--U.S. supply-demand balance for years ending June 30

Item	Nitrogen 1989	Nitrogen 1990	Nitrogen 1991 1/	Phosphate 1989	Phosphate 1990	Phosphate 1991 1/	Potash 1989	Potash 1990	Potash 1991 1/
				Million nutrient tons					
Producers' beginning inventory	1.35	1.51	1.14	0.55	0.70	0.52	0.16	0.22	0.34
Production	14.02	13.58	13.76	3/ 11.72	3/11.71	11.99	1.63	1.83	1.78
Imports	2/ 1.61	2/ 1.35	1.34	0.07	0.07	0.07	4.07	4.16	4.13
Total available supply	4/ 16.99	4/16.44	16.24	12.34	12.48	12.57	5.86	6.21	6.26
Agricultural consumption	10.59	11.08	10.71	4.12	4.34	4.15	4.84	5.20	5.17
Exports	2.92	3.14	3.21	5/ 4.80	5.49	5.51	0.40	0.39	0.45
Total agricultural and export demand	13.52	14.21	13.92	5/ 8.92	9.84	9.66	5.24	5.59	5.61
Producers' ending inventory	1.51	1.14	1.23	0.70	0.52	0.61	0.22	0.34	0.36
Available for non-agricultural use	4/ 1.97	4/ 1.09	1.09	2.72	2.12	2.30	0.40	0.27	0.28

1/ Forecast. 2/ Does not include anhydrous ammonia; effective January 1989, reporting of quantity data for anhydrous ammonia was discontinued by the U.S. Department of Commerce. Anhydrous ammonia typically accounts for 50-70 percent of total nitrogen imports; consequently, nitrogen imports are significantly understated. 3/ Does not include phosphate rock. 4/ Significantly understated due to lack of import data for anhydrous ammonia. 5/ Due to a data reporting change by the U.S. Department of Commerce, exports of superphosphoric acid are not included prior to January 1989. Thus, phosphate exports and total agricultural and export demand are understated.

Sources: (2, 3, 6, 7, 8).

Transportation difficulties may trigger some regional shortages of fertilizer materials this Spring. The U.S. rail system is still plagued by hopper car shortages during peak demand periods, which could trigger spot fertilizer shortages in some areas or higher prices if additional transportation costs are passed on to farmers.

Weaker market conditions reduced or halted nitrogen production in some plants during 1989/90. However, production rates for July-October 1990 indicate that about 97 percent of U.S. anhydrous ammonia capacity was being used (9). Wet-process phosphoric acid facilities, capable of producing almost 12.0 million tons of product a year, operated at 103 percent of capacity through October. During the same period in 1989, anhydrous ammonia and wet-process phosphoric plants operated at about 96 percent of capacity.

U.S. potash facilities operated at 83 percent of capacity, producing 0.7 million tons through October 1990; Canadian facilities operated at 59 percent, producing 2.4 million tons. A year earlier, potash plants in both the United States and Canada operated at 88 and 51 percent of capacity, respectively.

Nitrogen production is projected to increase about 1 percent in 1990/91 from the previous year. U.S. nitrogen imports will slip less than 1 percent, the decrease due to reduced domestic demand. However, higher domestic prices should encourage inventory accumulations. Producers have been increasing output since the crisis in the Persian Gulf in anticipation of higher feedstock prices in the future (natural gas). Shipments will continue to come from Canada, the USSR, and Trinidad-Tobago, with Canada being the major U.S. supplier of nitrogen (1). During 1989/90, anhydrous ammonia production dipped 3 percent to 16.3 million tons (table 3). Decreased production of other nitrogen materials ranged from 4 percent for urea to 7 percent for nitrogen solutions.

U.S. phosphate production is expected to increase marginally in 1990/91 in response to higher prices. Reduced domestic demand is anticipated, but continued strength in the export market is expected. Total production of selected phosphate fertilizer materials decreased 1 percent in 1989/90 from a year earlier. Diammonium phosphate production, which accounts for the largest proportion of U.S. phosphate fertilizer production, rose 2 percent. Production of normal and enriched superphosphate dropped 23 percent in 1989/90, and triple superphosphate production decreased about 14 percent.

In 1990/91, domestic potash production will likely decrease by about 2 percent in response to higher operating costs and less anticipated planted acreage. However, U.S. potash imports are expected to remain about the same as last year as U.S. suppliers increase inventories in anticipation of higher prices.

Table 3--U.S. production of selected fertilizer materials for years ending June 30

Material	1989	1990 1/	Annual change
	---1,000 tons---		Percent
Nitrogenous fertilizers: 2/			
Anhydrous ammonia 3/	16,863	16,343	-3
Ammonium nitrate, solid	2,312	2,166	-6
Ammonium sulfate	2,394	2,423	1
Urea 3/	8,159	7,808	-4
Nitrogen solutions	3,072	2,864	-7
Phosphate fertilizers: 4/			
Normal and enriched superphosphate	76	58	-23
Triple superphosphate	939	812	-14
Diammonium phosphate	6,112	6,233	2
Other ammonium phosphates and other phosphatic fertilizer materials	1,199	1,166	-3
Total 5/	8,326	8,269	-1
Wet-process phosphoric acid 6/	10,981	11,083	1
Muriate of potash: 7/			
United States	1,628	1,827	12
Canada	8,916	7,466	-16

1/ Preliminary. 2/ Total not listed because nitrogen solutions are in 1,000 tons of N, while other nitrogen products are in 1,000 tons of material. 3/ Includes material for nonfertilizer use. 4/ Reported in 1,000 tons P2O5. 5/ Totals may not add due to rounding. 6/ Includes merchant acid. 7/ Reported in 1,000 tons of K2O.

Sources: (2, 8).

Farm Prices

Spring 1991 fertilizer prices will likely increase 5 to 9-percent above their year-earlier levels. A tightening demand-supply situation combined with uncertainties over the Persian Gulf crisis has put upward pressures on prices. Higher transportation costs will also contribute to the increase in fertilizer prices.

Nitrogen prices will likely increase the most over fall prices as domestic supplies tighten and production costs of anhydrous ammonia increase. The major production cost of anhydrous ammonia is its feedstock, such as natural gas, fuel oil, or refinery gas. Phosphate and potash prices will also be higher than fall levels as the export market demonstrates continued strength.

Fertilizer prices paid by farmers decreased slightly (less than 1 percent) from October 1989 to April 1990. Prices fell again in late spring of 1990 due to excess supplies. Demand and supply were more in balance just prior to the Persian Gulf crisis in August. October farm prices include the initial shock of the crisis and reflect an increase between 1 and 2 percent over April 1990 farm prices.

The 1990 price performance follows a relatively sharp downturn between April and October 1989 in average farm fertilizer prices. After rising steadily from October 1986 to April

Table 4--Average U.S. farm prices for selected fertilizer materials 1/

Year	Anhydrous ammonia (82%)	Urea (44-46%)	Triple superphosphate (44-46%)	Diammonium phosphate (18-46-0%)	Potash (60%)	Mixed fertilizer (6-24-24%)	Prices-paid index (1977=100)
	$/ton						
1985:							
May	252	217	203	240	128	192	135
October	237	204	195	229	113	182	130
1986:							
April	225	174	190	224	111	179	125
October	174	159	182	205	107	173	116
1987:							
April	187	161	194	220	115	176	117
October	180	159	206	231	135	183	121
1988:							
April	208	183	222	251	157	208	132
October	191	188	221	246	157	208	134
1989:							
April	224	212	229	256	163	217	141
October	180	172	204	218	153	196	131
1990:							
April	199	184	201	219	155	198	130
October	191	199	205	228	150	201	132

1/ Based on a survey of fertilizer dealers conducted by the National Agricultural Statistics Service, USDA.

1989, prices then fell 7 percent by October 1989 (table 4). Prices of nitrogen fell more than for other fertilizers, with anhydrous ammonia and urea prices down about 20 percent from April. Phosphate prices also fell considerably from April to October 1989; triple superphosphate and diammonium phosphate prices slid 11 and 15 percent. Potash price declines were limited by the January 1988 agreement between the U.S. Department of Commerce and Canadian potash producers, restricting Canadian producers from dumping potash in the United States.

U.S. Fertilizer Trade

Anhydrous ammonia accounts for 35-60 percent of total nitrogen material imports and 25 percent of total nitrogen material exports. During calendar year 1989 the Department of Commerce (DOC) ceased reporting quantity data for anhydrous ammonia trade. The DOC took this action in response to a disclosure petition filed by a fertilizer importer. Although data for 1990 are now available, the quantity of U.S. fertilizer trade data will be understated for 1989.

Fertilizer import volume in 1989/90 decreased about 12 percent from a year earlier, and value dropped off 16 percent (table 5). Imports totaled approximately 11.0 million tons (7.7 million nutrient tons), valued at $1.2 billion. Canada provided a substantial share of U.S. nitrogen imports and almost all potash imports.

Fertilizer exports totaled 24.6 million tons (9.0 million nutrient tons), about the same as 1988/89 (table 6). Countries of Asia provided the largest markets, followed by Canada and Latin America. China and India each received about 13 percent of all U.S. fertilizer exports; South Korea, Mexico, the Netherlands, Japan, and Canada imported over 18, 13, 12,

Table 5--U.S. imports of selected fertilizer materials

Material	Fertilizer year 1988/89	Fertilizer year 1989/90	July-October 1989	July-October 1990
	1,000 tons			
Nitrogen:				
Anhydrous ammonia 1/	1,947	1,322	1/	907
Aqua ammonia	635	41	26	4
Urea	2,241	1,933	550	703
Ammonium nitrate	414	443	114	128
Ammonium sulfate	357	422	100	71
Sodium nitrate	156	141	22	53
Calcium nitrate	120	104	28	18
Nitrogen solutions	632	489	94	89
Other	82	52	10	15
Phosphate:				
Ammonium phosphates	69	15	4	2
Crude phosphates	1,073	434	154	163
Phosphoric acid 2/	2	2	1	*
Normal and triple superphosphate	*	2	1	1
Other	2	5	2	*
Total	1,145	458	162	166
Potash:				
Potassium chloride	6,567	6,703	1,779	2,074
Potassium sulfate	90	56	10	20
Potassium nitrate 3/	91	41	11	22
Total	6,748	6,800	1,800	2,116
Mixed fertilizers	145	288	90	63
Total	12,676	11,171	2,996	3,426
	$ billion			
Total value 4/	1.39	1.17	0.32	0.35

* = Less than 500 tons.

1/ During calendar year 1989, reporting of quantity data for anhydrous ammonia was discontinued by the U.S. Department of Commerce, but was reinstated in 1990. Fertilizer year 1988/89 contains anhydrous ammonia data for the first 6 months while fertilizer year 1989/90 contains data for the last 6 months. 2/ Includes all forms of phosphoric acid. 3/ Includes potassium sodium nitrate. 4/ Value by fertilizer material in appendix table 1.

Source: (7).

Table 6--U.S. exports of selected fertilizer materials 1/

Material	Fertilizer year 1988/89	Fertilizer year 1989/90	July-October 1989	July-October 1990
	1,000 tons			
Nitrogen:				
Anhydrous ammonia	612	511	165	237
Aqua ammonia	14	15	10	0
Urea	1,025	1,249	608	331
Ammonium nitrate	65	149	71	3
Ammonium sulfate	842	933	331	417
Sodium nitrate	2	2	1	1
Nitrogen solutions	680	429	148	195
Other	61	37	16	11
Total	3,301	3,325	1,350	1,195
Processed phosphate:				
Normal super-phosphate	22	22	9	18
Triple super-phosphate	740	731	229	248
Diammonium phosphate	7,941	9,035	3,865	2,673
Monoammonium and other ammonium phosphates	862	917	364	219
Phosphoric acid--				
Wet-process	584	729	348	277
Super	6	72	23	92
Other	37	119	96	91
Total	10,192	11,625	4,934	3,618
Phosphate rock 2/	10,020	8,336	2,905	2,186
Potash:				
Potassium chloride	477	423	192	279
Potassium sulfate	192	209	30	75
Other	284	343	128	97
Total	953	975	350	451
Mixed fertilizers	172	318	130	81
Total	24,638	24,579	9,669	7,531

1/ Declared value of exports not reported after 1985.
2/ Effective January 1984, phosphate rock exports include a small tonnage of miscellaneous fertilizers.

Source: (6).

10, and 8 percent, respectively, of phosphate rock exports. During July-October 1990, U.S. exports fell by about 22 percent as purchases by India and China returned to more historic levels compared with the corresponding time period a year earlier.

During the first 4 months of fertilizer year 1990/91 (July-October), fertilizer import volume increased about 14 percent (table 5). Exports decreased 22 percent from a year earlier for this same time period (table 6). Imports of potassium chloride, the major source of potash, increased 17 percent. Processed phosphate exports dropped 27 percent, and phosphate rock exports fell 25 percent.

Nitrogen Trade

Imports of all nitrogen materials except ammonium nitrate and ammonium sulfate decreased in 1989/90. Urea and nitrogen solution imports declined 14 and 30 percent; sodium nitrate imports went down 10 percent. Urea imports, which declined from 2.2 to 1.9 million tons, represented 34 percent of all nitrogen material imports during the previous fertilizer year.

In 1989/90 Canada remained the major foreign supplier of nitrogen fertilizer, providing about 41 percent of U.S. import tonnage. On a value basis, Canada was the major source of U.S. anhydrous ammonia imports, earning over 57 percent of anhydrous ammonia import value. Canada also provided most of the imported urea, supplying about 67 percent of the 1.9 million tons of U.S. imports. Trinidad-Tobago and Mexico each shipped another 5 percent.

In 1989/90 the volume of all nitrogen material exports increased from the previous year. Overall nitrogen exports rose 1 percent. Urea exports increased 22 percent and made up 40 percent of the 3.1 million tons of nitrogen materials exported; ammonium sulfate, 30 percent; nitrogen solutions, 14 percent; anhydrous ammonia, 9 percent; and ammonium nitrate, 5 percent (table 6). Diammonium phosphate (18 percent nitrogen and 46 percent phosphate) accounted for over 55 percent of the 3 million nutrient tons of nitrogen exported and 76 percent of the processed phosphate.

Brazil was the largest customer for U.S. ammonium sulfate, purchasing 29 percent of the 0.9 million tons exported. China, France, Chile, and Canada purchased the most urea, importing 29, 17, 11, and 7 percent. Belgium-Luxembourg was the largest purchaser of nitrogen solutions, taking 55 percent of the total.

Phosphate Trade

At 11.6 million tons, U.S. phosphate fertilizer exports in 1988/89 jumped 14 percent from the previous year. India and China were the largest purchasers of U.S. phosphate fertilizer in 1988/89, accounting for 25 and 24 percent of phosphate exports, respectively. Other important customers were Canada, Chile, Colombia, and Venezuela. Although data on exports of superphosphoric acid to the USSR are not available, the Soviets buy large amounts of U.S. phosphate fertilizer.

Exports of all phosphate fertilizer materials increased—except for triple superphosphate, which fell 1 percent. Exports of phosphoric acid, diammonium phosphates, and monoammonium phosphates went up 25, 14, and 6 percent. India purchased 70 percent of all U.S. phosphoric acid exports. Chile received about 23 percent (165,000 tons) of concentrated superphosphate exports. China received 30 percent (2.8 million tons) of diammonium phosphate exports, and Canada imported 27 percent (260,000 tons) of monoammonium phosphate exports. South Korea purchased the most U.S. phosphate rock, accounting for 18 percent of all exports, while Mexico, the Netherlands, Japan, France and Canada took 13, 12, 10, 8, and 8 percent.

At 8.3 million tons, U.S. phosphate rock exports declined 17 percent in 1989/90, continuing a trend toward the shipping

Table 7--U.S. fertilizer consumption 1/

Year ending June 30 2/	Total fertilizer materials	Primary nutrient use N	P205	K20	Total 3/	(1977=100)
		------------Million tons----------------				Percent
1977	51.6	10.6	5.6	5.8	22.1	100
1980	52.8	11.4	5.4	6.2	23.1	104
1981	54.0	11.9	5.4	6.3	23.7	107
1982	48.7	11.0	4.8	5.6	21.4	97
1983	41.8	9.1	4.1	4.8	18.1	82
1984	50.1	11.1	4.9	5.8	21.8	99
1985	49.1	11.5	4.7	5.6	21.7	98
1986	44.1	10.4	4.2	5.1	19.7	89
1987	43.0	10.2	4.0	4.8	19.1	86
1988	44.5	10.5	4.1	5.0	19.6	89
1989	44.9	10.6	4.1	4.8	19.6	89
1990	47.7	11.1	4.3	5.2	20.6	93

1/ Includes Puerto Rico. Detailed State data shown in appendix table 2. 2/ Fertilizer use estimates for 1977-84 are based on USDA data; those for 1985-89 are TVA estimates. 3/ Totals may not add due to rounding.

Source: (3).

of processed phosphate fertilizer rather than rock. The phosphate rock of other exporting countries has a higher ore content than that of the United States.

Potash Trade

U.S. potassium chloride imports increased about 1 percent in 1989/90 to 6.7 million tons (table 5). Potassium chloride accounted for almost all potash imports, with Canada providing 94 percent of the total, up from 89 percent the previous year. Israel and Germany were the only other significant suppliers, shipping 5 and 1 percent.

U.S. exports of potassium fertilizer materials increased about 2 percent in 1989/90. Approximately 1 million tons were shipped, with potassium chloride accounting for 43 percent of the total, which was down 11 percent from the previous year's total (table 6). Potassium sulfate exports went up 9 percent, comprising 21 percent of potassium exports.

Fertilizer Use Estimates

In 1989/90, 47.7 million tons of fertilizer material were used in the United States and Puerto Rico, up 6 percent from the previous year (table 7). Use of plant nutrients of 20.6 million tons represented an increase of 5.3 percent from the previous year. Nitrogen use increased 4.2 percent to 11.1 million tons, while phosphate and potash use climbed 5.3 and 7.7 percent to 4.3 and 5.2 million tons.

Changes in 1989/90 regional consumption varied. Plant nutrient use fell as much as 8 percent in the Southern Plains region. In the Delta States region, it rose as much as 14 percent due to changes in planted acreage and a return to historical application rates for phosphate and potash. The previous year's rates reflected farmers' adjustments from the carryover effects of the 1988 drought (table 8). Nitrogen use increased in all regions except the Northeast and Southern Plains regions, where it dropped 2 and 8 percent (table 9). Use of phosphate decreased 8 percent in the Southern Plains region, but rose in all others. Potash use increased in all regions except the Southern Plains, where it declined 4 percent.

The proportion of fertilizers applied as single nutrient materials retained market share, constituting 59 percent of U.S. fertilizer use in 1989/90 (table 10). Farmers continued their trend toward utilization of more concentrated materials to meet plant nutrient needs.

Corn for Grain

Fertilizer was applied to 97 percent of the corn acres in 1989/90 (table 11). The proportion of acres fertilized with nitrogen remained unchanged, while the proportion of acres fertilized with phosphate and potash increased. Application rates of nitrogen, phosphate, and potash increased slightly from a year earlier to 132, 60, and 84 pounds per acre (see special article on testing for statistically significant differences in mean application rates between 1989 and 1990).

Cotton

About 80 percent of cotton acreage received some fertilizer in 1989/90, up 1 percent from a year earlier, as the proportion of acres fertilized with nitrogen remained the same and the proportion fertilized with phosphate and potash decreased from last year. Application rates for nitrogen, phosphate, and potash increased to 86, 44, and 47 pounds per acre.

Rice

Fertilizer was applied on 98 percent of the rice acreage in 1989/90; the proportion of acres treated with the various nutrients ranged from 97 percent for nitrogen to 36 percent for phosphate. The application rate for nitrogen dropped from a year earlier to 114 pounds per acre; rates for phosphate re-

Table 8--Regional plant nutrient consumption for year ending June 30 1/

Region	1989	1990	Annual change
	1,000 tons		Percent
Northeast	733	764	4
Lake States	2,340	2,583	10
Corn Belt	6,269	6,681	7
Northern Plains	2,331	2,434	4
Appalachia	1,479	1,586	7
Southeast	1,498	1,536	3
Delta States	927	1,060	14
Southern Plains	1,708	1,575	-8
Mountain	933	987	6
Pacific 2/	1,341	1,389	4
U.S. total 3/	19,558	20,596	5.3

1/ Includes N, P2O5, and K2O. Totals may not add due to rounding. 2/ Includes Alaska and Hawaii. 3/ Excludes Puerto Rico. Detailed State data shown in appendix table 2.

Source: (3).

Table 9--Regional plant nutrient use for year ending June 30 1/

Region	1989	1990	Annual change
	---1,000 tons---		Percent
Nitrogen:			
Northeast	313	306	-2
Lake States	1,011	1,134	12
Corn Belt	3,041	3,215	6
Northern Plains	1,680	1,751	4
Appalachia	613	667	9
Southeast	643	670	4
Delta States	560	643	15
Southern Plains	1,217	1,117	-8
Mountain	626	642	3
Pacific 2/	916	921	1
U.S. total 3/	10,619	11,065	4.2
Phosphate:			
Northeast	188	198	5
Lake States	477	508	6
Corn Belt	1,254	1,334	6
Northern Plains	522	550	5
Appalachia	361	381	6
Southeast	297	308	4
Delta States	154	177	15
Southern Plains	342	315	-8
Mountain	253	279	10
Pacific 2/	270	289	7
U.S. total 3/	4,119	4,340	5.4
Potash:			
Northeast	232	261	12
Lake States	852	941	11
Corn Belt	1,974	2,132	[illegible]
Northern Plains	129	133	[illegible]
Appalachia	506	538	6
Southeast	558	559	0
Delta States	212	240	13
Southern Plains	149	143	-4
Mountain	53	65	23
Pacific 2/	155	179	15
U.S. total 3/	4,820	5,192	7.7

1/ Totals may not add due to rounding. 2/ Includes Alaska and Hawaii. 3/ Excludes Puerto Rico. Detailed State data shown in appendix table 2.

Source: (3).

Table 10--Average annual U.S. fertilizer use 1/

Year ending June 30 4/	Multiple nutrient 2/ Quantity	Multiple nutrient 2/ Share of total	Single nutrient 3/ Quantity	Single nutrient 3/ Share of total
	Million tons	Percent	Million tons	Percent
1980	23.3	44	29.5	56
1981	23.5	44	30.5	56
1982	20.9	43	27.8	57
1983	18.4	44	23.5	56
1984	21.2	42	28.9	58
1985	20.6	44	26.7	56
1986	17.8	42	24.7	58
1987	17.1	42	24.1	58
1988	17.6	41	25.1	59
1989	17.6	41	25.2	59
1990	18.4	41	26.9	59

1/ Includes Puerto Rico. 2/ Fertilizer materials that contain more than one primary nutrient. 3/ Materials that contain only one nutrient. 4/ Fertilizer use estimates for 1980-84 are based on USDA data; those for 1985-90 are TVA estimates.

Source: (3).

mained the same at 45 pounds, while potash rates increased to 49 pounds.

Soybeans

Some fertilizer was applied to 31 percent of soybean acres planted in 1989/90, up 3 percent from the previous year as the proportion of acres fertilized was unchanged for nitrogen and declined for phosphate and potash. However, application rates for all three nutrients increased from the preceding year. Application rates were the highest for potash at 81 pounds per acre, followed by phosphate at 47 pounds and nitrogen at 24 pounds. Some differences in application rates between the Northern and Southern regions existed, with the North applying less nitrogen per acre, an equal amount of phosphate, and more potash.

Wheat

The share of wheat acres fertilized decreased to 79 percent in 1989/90. The proportion of acres treated with nitrogen fell to 79 percent, and the proportion treated with phosphate decreased to 52 percent. Potash-treated acres increased to 19 percent. Nitrogen and potash application rates decreased to 59 and 44 pounds per acre; the rate for phosphate also went down from the previous year.

World Fertilizer Review and Prospects

World plant nutrient production and use increased in 1987/88 and is projected to have expanded in 1988/89 and 1989/90. Fertilizer production and consumption rose significantly in developing market economies (Asia, Africa, and Latin America), but only slightly in developed market economies. However, changes in Central and Eastern Europe, the crisis in the Persian Gulf, and other world developments could reduce production and consumption and result in lower estimates.

Table 11--Fertilizer use on selected U.S. field crops 1/

Crop, year	Acres receiving: Any fertilizer	N	P205	K20	Application rates: N	P205	K20
	Percent				Lbs./ acre		
Corn for grain:							
1985	98	97	86	79	140	60	84
1986	96	95	84	76	132	61	80
1987	96	96	83	75	132	61	85
1988	97	97	87	78	137	63	85
1989	97	97	84	75	131	59	81
1990	97	97	85	77	132	60	84
Cotton:							
1985	76	76	50	34	80	46	52
1986	80	80	50	39	77	44	50
1987	76	76	47	33	82	44	45
1988	80	80	54	32	78	42	39
1989	79	79	54	32	84	43	40
1990	80	79	49	31	86	44	47
Rice:							
1988	99	99	46	36	127	47	50
1989	99	99	46	33	125	45	45
1990	98	97	36	37	114	45	49
Soybeans:							
1985	32	17	28	30	15	43	72
1986	33	18	29	31	15	43	71
1987	30	15	25	28	20	47	75
1988	32	16	26	31	22	48	79
1989	34	17	28	32	18	46	74
Northern area	30	14	23	28	16	48	77
Southern area	44	24	42	44	21	43	67
1990	31	17	24	29	24	47	81
Northern area	27	14	20	25	22	47	87
Southern area	41	26	38	39	28	47	70
All wheat:							
1985	77	77	48	16	60	35	36
1986	79	79	48	19	60	36	44
1987	80	80	50	15	62	35	43
1988	83	83	53	18	64	37	52
1989	81	81	53	18	62	37	46
1990	79	79	52	19	59	36	44

1/ Detailed data for selected States by crop shown in appendix tables 3-7.

World Supplies

In 1988/89, world plant nutrient supplies are projected to have increased over 4 percent to 152.9 million metric tons (table 12). Nitrogen supplies expanded 5 percent to 81.7 million tons; phosphate supplies rose by 3 percent to 40.2 million metric tons. Potash supplies reached 31.0 million metric tons (an increase of about 3 percent). Reduced potash production probably decreased world plant nutrient supplies less than 1 percent in 1989/90. However, planted acreage outside the United States was projected to expand, encouraging increased fertilizer production and consumption.

Consumption

World plant nutrient consumption in 1988/89 increased over 5 percent from a year earlier to about 145.7 million metric tons (table 12). Nitrogen use climbed about 5 percent, while phosphate use rose 4 percent and potash 3 percent. Nitrogen, phosphate, and potash consumption increased to about 80, 38, and 28 million metric tons. In 1989/90, world plant nutrient use rose an estimated 1 percent due to increased demand in the developing market economies of Latin America and Asia.

Table 12--World plant nutrient supply and consumption for years ending June 30

Plant nutrient	1988	1989 1/	1990 1/
	Million metric tons		
Available supply: 2/			
Nitrogen	78.0	81.7	81.8
Phosphate	39.1	40.2	40.4
Potash	30.1	31.0	30.4
Total 3/	147.2	152.9	152.6
Consumption:			
Nitrogen	75.5	79.6	80.7
Phosphate	36.7	38.1	38.0
Potash	27.3	28.0	27.1
Total 3/	139.5	145.7	145.8

1/ Projected. 2/ Production less industrial uses and losses in transportation, storage, and handling.
3/ Totals may not add due to rounding.

Source: (4, 5).

World Trade Developments

Existing nitrogen trade patterns should continue. Canada, Eastern Europe, and the USSR will continue to supply nitrogen fertilizer to the United States, Western Europe, and Asia. Additional nitrogen fertilizer production in Canada and Trinidad-Tobago will compete for a share of the already-crowded

North American, West European, and Mediterranean markets. Surplus nitrogen from the Near East will probably move to Asian markets.

Phosphate production is expected to grow in most regions. Although U.S. consumption is stabilizing, world consumption will increase, tightening the supply-demand balance. Asia should have the most active trade, since countries in that region are expected to produce only a small share of the phosphate they need. The African and U.S. phosphate industries will compete for this growing market.

Canada, Germany, Israel, and the USSR are the major potash exporters. Canadian exports are expected to outdistance those of other major exporters by further penetrating the large Indian and Chinese markets and continuing shipments to the United States.

World Fertilizer Prices

Intensified use of fertilizer in developing countries has increased world consumption, a trend forecast to continue in the 1990's. World consumption rose by about 4.4 percent in 1988/89, while available supply increased 3.8 percent. Heightened demand and the crisis in the Persian Gulf will tighten supplies and raise world prices in 1990/91 over fall 1990 prices. The long-awaited resumption of Chinese and Indian demand, as well as strong U.S. import demand, will fuel upward price trends in the future.

Global Projections to 1995

According to 1990 forecasts of the Food and Agriculture Organization/United Nations Industrial Development Organization/World Bank/Industry Working Group, world nitrogen, phosphate, and potash fertilizer consumption is expected to grow 8, 6, and 1 percent during 1990-95 (table 13). Fertilizer production and use are projected to grow fastest in developing countries and the centrally planned economies of Asia.

In developed countries, consumption is expected to decline 2 percent or expand less than 1 percent by 1995, down from earlier projections of over 10-percent growth. The reduction in the rate of growth in U.S. consumption forecasts assumes continuation of acreage setaside programs. Stable demand in Western Europe will also slow growth in world fertilizer use and curb nitrogen and phosphate production rates. North American potash exports to South America are expected to rise, supporting growth in U.S. and Canadian potash production. Smaller potash production increases in Eastern Europe and the USSR could reduce those countries' exports.

In the developing countries, the supply potential for nitrogen and phosphate is expected to climb 16 and 24 percent by 1995, but that for potash will decline by 3 percent. Consumption will be up by 24 percent. The rapid rise in consumption can be attributed to the goal of many developing countries to become self-sufficient in food and fertilizer production.

Table 13--Projected 1990-95 change in world fertilizer supply and consumption 1/

World regions	Nitrogen	Phosphate	Potash
	Percent increase		
Supply potential:			
Developed market economies	3	-0	-1
Developing market economies	24	16	-3
Eastern Europe and the USSR	2	-0	-2
Centrally planned countries of Asia	8	16	40
Total	9	5	-1
Consumption:			
Developed market economies	-2	-2	1
Developing market economies	24	23	24
Eastern Europe and the USSR	0	-5	-17
Centrally planned countries of Asia	10	15	33
Total	8	6	1

1/ Detailed data in appendix table 8.

Source: (4).

Nitrogen demand growth in both Western Europe and the United States is uncertain. Plants that closed during the past several months may reopen in anticipation of higher prices resulting from tighter world supplies and the crisis in the Persian Gulf.

Nitrogen production in the developed countries is expected to increase about 3 percent during the next 5 years, while both phosphate and potash production will slightly decrease. Most of the nitrogen increase will come from greater Canadian production. Higher phosphate fertilizer production in the United States will depend heavily on phosphate export potential.

New and more efficient ammonia plants are scheduled to be completed during the next few years in Canada, Trinidad-Tobago, the United Kingdom, and Belgium. New urea plants are planned for Saudi Arabia, Indonesia, Bangladesh, India, Pakistan, Java, and China. Nitrogen production is expected to increase near natural gas reserves in Indonesia, India, Saudi Arabia, Mexico, and Trinidad-Tobago. Among centrally planned economies in Asia and in Eastern Europe, greater nitrogen production capacity will be limited mainly to those plants built in China. France, the Netherlands, and the United Kingdom are also expected to also expand production.

This surplus of nitrogen production capacity will likely provide sufficient supplies until the year 1995. However, the world will then need more production capacity; price increases will therefore be needed to make it profitable to expand production to meet demand.

Africa, Asia, Oceania, and Western Europe are projected to have nitrogen deficits through 1995. Eastern Europe, Latin America, the Near East, and the USSR will have surpluses because countries like these, with plentiful natural gas resources, produce nitrogen fertilizer for export.

Phosphate production will center primarily in the United States, the USSR, and Morocco during 1990-95. About 33 percent of the phosphoric acid supply capability will be located in the United States, 20 percent in the USSR, and 10 percent in Morocco. Increased phosphate production in India, China, Mexico, Tunisia, and Brazil will also add to world supplies.

The developed countries and Africa are projected to have surpluses of phosphate fertilizer; the USSR, Asia, and Eastern Europe will be deficit areas, with Asia having the most acute shortage.

Worldwide, phosphate rock capacity will be more than adequate to meet demand, with the main surplus areas being North America and Africa. Jordan and Morocco are major phosphate producers and have large capacity additions planned for the next 5 years. The USSR and India are forecast to be the world's largest importers of phosphoric acid, accounting for an estimated 45 percent of world trade. China, Brazil, Mexico, and India will also remain significant importers of processed phosphates through the early 1990's, since the excavation of new phosphate mines in those countries will take a long time and their phosphate rock processing facilities have not been fully developed.

Potash supply capability should be adequate into the next decade, but world potash production potential is expected to decrease about 1 percent. The greatest surplus is forecast for North America, due to heightened Canadian production. Israel, Jordan, Brazil, Thailand, and China will add to worldwide capacity. Potash capacity in Western Europe may decline as mines close in Germany and France. Nor is any significant development expected for the next few years in Chile, the Congo, Ethiopia, Thailand, or Tunisia.

Eastern Europe and the USSR will have major potash surpluses even though production has been reduced by over 1 million tons during the reunification of Germany. Western Europe, Asia, Africa, and Latin America are projected to be deficit areas.

Projected regional shares of world fertilizer supply and demand indicate a continued shift in production and use from the developed to the developing countries. The centrally planned countries' share of world production will remain relatively constant through 1995 at around 46 percent for nitrogen, 33 percent for phosphate, and 41 percent for potash. Their consumption of each nutrient will also remain about the same—35 to 44 percent (table 14).

References

1. Agriculture Canada. *Market Commentary: Farm Inputs and Finance*, December 1989.

2. Potash/Phosphate Institute. Selected reports. Atlanta, Ga.

Table 14--Projected regional shares of world fertilizer supply potential and demand for years ending June 30

World regions	Nitrogen		Phosphate		Potash	
	1990	1995	1990	1995	1990	1995
	Percent					
Supply potential:						
Developed market economies	26.4	24.8	43.7	41.6	55.9	56.2
North America	13.5	13.4	24.4	23.9	34.5	34.5
Western Europe	11.2	10.1	12.6	11.1	17.4	17.3
Oceania	0.5	0.4	2.7	2.7	0.0	0.0
Other countries	1.1	0.9	4.0	3.8	4.0	4.4
Developing market economies	25.4	29.0	23.7	26.1	2.9	2.8
Africa	0.7	0.8	10.2	11.7	0.0	0.0
Latin America	5.7	5.7	4.8	4.7	0.2	0.0
Asia	19.0	22.5	8.8	9.7	2.6	2.8
Eastern Europe and USSR	29.6	27.7	24.3	23.1	41.0	40.7
Centrally planned countries of Asia	18.6	18.5	8.3	9.1	0.2	0.3
Consumption:						
Developed market economies	29.7	26.9	31.4	28.9	42.5	42.3
North America	14.4	13.2	12.1	10.9	18.8	18.8
Western Europe	13.4	11.7	13.3	12.1	20.1	19.7
Oceania	0.6	0.7	3.3	3.3	0.9	1.0
Other countries	1.4	1.3	2.7	2.7	2.7	2.8
Developing market economies	26.1	29.9	26.3	30.4	18.1	22.2
Africa	1.0	1.2	1.7	2.3	1.1	1.4
Latin America	4.8	5.2	6.8	7.7	7.9	9.5
Asia	20.2	23.6	17.8	20.5	9.1	11.3
Eastern Europe and USSR	19.3	17.9	27.6	24.7	33.3	27.4
Centrally planned countries of Asia	24.9	25.3	14.7	15.9	6.1	8.0

Source: (4).

3. Tennessee Valley Authority, National Fertilizer and Environmental Research Center. *Commercial Fertilizer Consumption*, December 1990.

4. United Nations Food and Agriculture Organization. *Current World Fertilizer Situation and Outlook, 1988/89 to 1994/95*, Rome, 1990.

5. *1988 Fertilizer Yearbook*, Rome, 1989.

6. U.S. Department of Commerce, Bureau of the Census. *U.S. Exports, Commodity and Country*, FT-410. October 1990 and earlier issues.

7. __________. *U.S. Imports, Commodity and Country*, FT-135, October 1990 and earlier issues.

8. __________. *Inorganic Fertilizer Materials and Related Products*, M28-B, October 1990 and earlier issues.

9. Tennessee Valley Authority, National Fertilizer and Environmental Research Center. *North American Fertilizer Capacity Data*, January 1991.

Pesticides

Consumption

Total farm pesticide use on the major field crops is projected at 481 million pounds active ingredients (a.i.) in 1991, up 3 percent from a year earlier (table 15). Planted acreage for all crops will likely rise, except wheat and perhaps barley, oats, and grain sorghum.

Herbicides account for 84 percent of total pesticide use, while insecticides make up 13 percent. The 12.2-million-pound a.i. rise in herbicide use expected in 1991 can largely be attributed to an expansion of 4 percent in corn acreage and 1 percent for soybeans. Corn and soybeans account for 82 percent of herbicide use.

Insecticide use in 1991 is expected to be up 6 percent from a year earlier, largely on the strength of a projected 18-percent increase in planted cotton acreage. Fungicide use for major field crops is expected to remain stable, with the most poundage being used in peanut production.

1990 Pesticide Use

Corn

Herbicides were used on 95 percent of the surveyed corn acreage in 1990 (table 16). South Dakota and Wisconsin farmers treated the fewest acres for weed control at 87 and 88 percent.

Table 15--Projected pesticide use on major U.S. field crops, 1991

Crops 1/	Herbicides	Insecticides	Fungicides
	Million pounds (a.i.)		
Row crops:			
Corn	228.9	28.3	0.06
Cotton	22.0	21.4	0.22
Grain sorghum	11.1	1.8	0.00
Peanuts	6.4	1.4	6.32
Soybeans	105.4	9.2	0.06
Tobacco	1.2	2.8	0.37
Total	375.0	64.9	7.03
Small grains:			
Barley and oats	4.4	0.1	0.00
Rice	12.6	0.5	0.07
Wheat	14.1	1.9	0.78
Total	31.1	2.5	0.85
1991 total	406.1	67.4	7.88
1990 total	393.9	63.5	7.96

1/ See table 1 for crop acreage.

In the 10 surveyed States, an average of 1.4 herbicide treatments were made to control weeds. A single herbicide treatment was used on 59 percent of the acreage and 2 treatments on 32 percent. Iowa with 44 percent and Minnesota with 42 percent had the highest proportion of corn acreage treated twice.

Atrazine used alone or in combination with other active ingredients was the most commonly used herbicide material, included in 45 percent of the acre-treatments. Atrazine + alachlor was the most commonly used combination mix, accounting for 10 percent of the acre-treatments. Both active ingredients control a large number of broadleaf and grass weeds and when applied in combination the control spectrum is broadened. Atrazine + metolachlor, as well as alachlor, atrazine, and metolachlor alone, were also widely used throughout the area. Metolachlor is from the same chemical family as alachlor.

EPTC accounted for 20 percent of the acre-treatments in South Dakota and 17 percent in Minnesota. EPTC controls many annual grasses, especially wild proso millet, a major problem in the northern Corn Belt. It is also more biologically active at low soil temperatures than many other preplant herbicide materials.

Minnesota and South Dakota treated much of their corn acreage with dicamba, 2,4-D, or a combinations of dicamba + 2,4-D. These materials are applied postemergence for broadleaf weed control.

Insecticides were used on 32 percent of the corn acreage in 1990 (table 17). Insecticide use was greatest in Nebraska, where 51 percent of the corn acreage was treated. In contrast, Minnesota and South Dakota farmers treated only 14 and 12 percent of their corn acreage. In Nebraska, corn rootworm larvae can be a problem because about two-thirds of

Table 16--Selected herbicides used in corn production, 1990

Item	IL	IN	IA	MI	MN	MO	NE	OH	SD	WI	Area
1,000 acres planted 1/	10700	5600	12800	2400	6700	2100	7700	3700	3400	3700	58800
1,000 acres treated with herbicides	10519	5448	12133	2263	6441	1908	7250	3534	2949	3261	55706
Percent of acres treated:	98	97	95	94	96	91	94	96	87	88	95
With 1 treatment	61	71	47	77	44	82	64	71	54	64	59
With 2 treatments	35	24	44	16	42	9	27	23	28	22	32
With 3 or more	2	2	4	1	10	0	3	2	5	2	4
Average acre-treatments	1.39	1.29	1.56	1.20	1.67	1.10	1.35	1.30	1.45	1.29	1.41
1,000 acre-treatments	14583	7010	18867	2709	10735	2100	9763	4578	4273	4202	78820
Acre-treatments by active ingredient: 2/						Percent					
Single materials--											
Alachlor	10	5	9	3	7	6	7	3	18	3	8
Atrazine	6	7	4	19	4	17	13	9	2	24	8
Bromoxynil	2	nr	3	nr	2	nr	nr	nr	1	1	2
Cyanazine	2	2	2	nr	6	3	3	3	2	6	3
Dicamba	5	5	5	3	15	2	2	10	17	6	7
EPTC	4	1	8	1	17	1	2	1	20	3	6
Metolachlor	11	4	17	3	11	1	1	3	4	4	9
2,4-D	5	3	5	4	9	2	6	2	11	1	5
Other	5	5	4	5	6	5	4	3	5	11	5
Combination mixes--											
2,4-D + dicamba	2	1	4	nr	3	nr	2	3	4	1	2
Atrazine + alachlor	7	26	5	15	2	15	22	16	3	7	10
Atrazine + bromoxynil	2	1	5	3	3	3	1	nr	1	nr	3
Atrazine + butylate	4	6	nr	3	nr	4	4	3	nr	nr	2
Atrazine + cyanazine	8	7	7	5	1	14	9	8	1	4	6
Atrazine + dicamba	7	5	4	nr	2	1	3	3	6	1	4
Atrazine + metolachlor	13	12	6	15	0	14	11	15	1	7	9
Atrazine + others	3	2	4	5	1	3	2	4	nr	1	3
Other 2-way mixes	1	2	4	5	7	2	3	5	4	11	4
3-way mixes	4	6	3	13	5	9	4	11	1	9	5
Total	100	100	100	100	100	100	100	100	100	100	100

nr = None reported.

1/ Preliminary. 2/ Spot treatments not included.

Table 17--Selected insecticides used in corn production, 1990

Item	IL	IN	IA	MI	MN	MO	NE	OH	SD	WI	Area
1,000 acres planted 1/	10700	5600	12800	2400	6700	2100	7700	3700	3400	3700	58800
1,000 acres treated with insecticides	3928	2038	4324	651	925	665	3894	949	391	1317	19082
Percent of acres treated:	37	36	34	27	14	32	51	26	12	36	32
With 1 treatment	34	36	33	26	14	32	35	26	11	36	29
With 2 treatments	3	0	1	1	0	0	13	0	1	0	3
With 3 treatments	0	0	0	0	0	0	1	0	0	0	*
Average acre-treatments	1.08	1.03	1.02	1.05	1.00	1.00	1.31	1.00	1.08	1.00	1.09
1,000 acre-treatments	4244	2095	4389	686	925	665	5088	949	421	1317	20779
Acre-treatments by active ingredient: 2/						Percent					
Carbofuran	7	4	3	20	4	5	7	8	21	10	7
Chlorpyrifos	20	15	22	20	16	26	18	30	14	24	20
Fonofos	15	16	12	20	12	5	7	20	36	7	12
Permethrin	6	5	3	5	4	16	nr	nr	nr	nr	3
Phorate	3	4	9	10	28	nr	4	5	21	7	6
Telfuthrin	6	11	2	5	4	nr	3	8	nr	2	4
Terbufos	33	44	47	15	32	16	41	30	7	50	38
Other	9	2	2	5	nr	32	21	nr	nr	nr	9
Total	100	100	100	100	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent

1/ Preliminary. 2/ Spot treatments not included.

Table 18--Selected herbicides used in northern soybean production, 1990

Item	IL	IN	IA	MN	MO	NE	OH	Area
1,000 acres planted 1/	9200	4300	8000	4600	4200	2400	3700	36400
1,000 acres treated with herbicides	9095	4198	7796	4557	3818	2260	3438	35162
Percent of acres treated:	99	98	97	99	91	94	93	97
With 1 treatment	50	64	41	46	75	68	75	56
With 2 treatments	44	30	49	44	13	26	14	36
With 3 or more	5	4	7	9	1	0	4	5
Average acre-treatments	1.54	1.38	1.66	1.64	1.22	1.27	1.25	1.48
1,000 acre-treatments	14009	5796	12920	7464	4641	2874	4289	51993
Acre-treatments by active ingredient: 2/					Percent			
Single materials--								
Alachlor	2	4	3	5	4	6	3	3
Bentazon	11	5	7	10	1	2	2	7
Chloramben	*	1	1	2	1	nr	2	1
Chlorimuron	3	1	3	nr	3	4	2	2
Clomazone	1	4	2	nr	4	5	1	2
Ethalfluralin	5	1	5	3	nr	nr	2	3
Fluazifop-P-butyl	1	3	2	2	1	1	1	2
Imazaquin	nr	1	*	*	8	2	2	1
Imazethapyr	4	5	12	20	6	7	3	9
Metolachlor	4	4	1	nr	3	1	3	2
Metribuzin	*	1	1	1	1	2	nr	1
Pendimethalin	3	1	4	5	4	4	1	3
Quizalofop-ethyl	1	nr	2	2	nr	nr	nr	1
Sethoxydim	4	2	3	2	1	nr	4	3
Trifluralin	12	5	24	26	11	21	2	16
Other	3	5	4	5	3	4	3	4
Combination mixes--								
Trifluralin + alachlor	3	nr	2	3	nr	nr	nr	2
Trifluralin + clomazone	2	2	5	1	1	6	nr	2
Trifluralin + imazaquin	3	2	nr	1	8	2	nr	2
Trifluralin + metribuzin	1	1	3	2	1	5	2	2
Metribuzin + alachlor	*	1	*	1	nr	nr	4	1
Metribuzin + chlorimuron	2	4	*	nr	2	2	6	2
Metribuzin + metolachlor	*	2	*	nr	*	*	4	1
Acifluorfen + bentazon	4	4	2	2	1	1	2	3
Alachlor + linuron	nr	4	nr	1	nr	1	2	1
Chlorimuron + thiameturon-methyl	1	1	5	1	nr	1	nr	2
Imazaquin + pendimethalin	3	3	nr	nr	16	3	5	3
Other 2-way mixes	9	11	5	2	9	12	16	8
Other combinations	13	21	5	2	12	10	29	12
Total	100	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent.

1/ Preliminary. 2/ Spot treatments not included.

the corn acreage is irrigated and a high proportion is planted to corn every year, allowing a buildup of the pest. In Minnesota and South Dakota, more of the corn acreage is rotated with other crops, including small grains, thus reducing corn rootworm problems.

Insecticides are generally applied at planting for corn rootworm larvae control. Insecticides are also used to control cutworms and European corn borers. Terbufos (38 percent) and chlorpyrifos (20 percent) were the most commonly used insecticides.

Soybeans

In 1990, 97 percent of the northern and 93 percent of southern soybean acreage in the surveyed States were treated with herbicides (tables 18 and 19). In the northern soybean region, farmers applied 1.5 treatments per acre, compared with 1.6 treatments per acre in the southern region. Normally, the difference between the two regions is larger, but this past year frequent rains disrupted weed control programs in the southern region, resulting in fewer herbicide treatments.

In the northern region, Iowa and Minnesota had the highest number of treatments per acre at 1.6. Farmers in these States typically use a preemergence herbicide and follow it with a postemergence application if additional weed problems arise. In the southern region, Georgia and North Carolina had the fewest treatments per acre at 1.3. In North Carolina a large proportion of the soybean acreage is double cropped with winter wheat. Because the soybeans are planted directly into the wheat stubble, less soil is disturbed and the leaf canopy is rapidly established, shading the ground and thereby inhibiting weed seed germination. In Georgia, drought conditions existed in 1990 making it less profitable to apply herbicides for weed control.

In the northern soybean region, trifluralin applied alone or in combination with other herbicides was the most commonly used material. Applied preplant incorporated, it controls

Table 19--Selected herbicides used in southern soybean production, 1990

Item	AR	GA	KY	LA	MS	NC	TN	Area
1,000 acres planted 1/	3100	900	1250	1800	2100	1400	1300	11850
1,000 acres treated with herbicides	2693	824	1250	1733	1925	1308	1290	11023
Percent of acres treated:	87	92	100	96	92	93	99	93
With 1 treatment	50	63	49	43	40	71	37	49
With 2 treatments	29	29	41	41	39	15	51	35
With 3 or more	8	0	10	12	13	7	11	9
Average acre-treatments	1.52	1.32	1.64	1.69	1.78	1.31	1.77	1.60
1,000 acre-treatments	4096	1089	2049	2933	3422	1717	2282	17588
Acre-treatments by active ingredient: 2/					Percent			
Single materials--								
Acifluorfen	3	nr	nr	[illegible]	1	3	[illegible]	2
Alachlor	1	3	3	nr	1	17	3	3
Bentazon	3	nr	2	1	3	1	2	2
Chlorimuron	3	9	1	5	6	6	6	5
Clomazone	nr	nr	nr	5	2	1	nr	1
Fluazifop-P-butyl	1	nr	12	7	1	nr	8	4
Fomesafen	2	1	2	4	1	nr	nr	2
Glyphosate	1	nr	5	4	2	1	1	2
Imazaquin	13	nr	3	4	6	2	15	7
Lactofen	3	1	*	nr	1	1	1	1
Metolachlor	6	1	1	5	1	nr	nr	3
Metribuzin	6	20	1	4	6	1	*	5
Pendimethalin	7	12	*	1	5	1	3	4
Sethoxydim	2	2	1	1	2	4	1	2
Trifluralin	22	25	9	10	19	7	21	16
Other	3	4	9	5	8	9	4	6
Combination mixes--								
Acifluorfen + bentazon	4	nr	4	3	5	2	2	3
Acifluorfen + imazaquin	1	nr	2	1	2	1	2	1
Alachlor + glyphosate	nr	nr	6	nr	1	8	*	2
Fluazifop-P-butyl + fomesafen	1	1	2	5	2	1	2	2
Imazaquin + pendimethalin	5	2	1	8	4	10	5	5
Imazaquin + trifluralin	6	nr	6	3	5	4	nr	4
Metribuzin + chlorimuron	1	1	1	1	2	nr	3	1
Metribuzin + trifluralin	1	3	nr	3	nr	1	1	1
Other 2-way mixes	2	11	13	11	9	11	7	8
Other combinations	3	4	15	7	6	10	9	7
Total	100	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent.

1/ Preliminary. 2/ Spot treatments not included.

many broadleaf and grass weeds. Imazethapyr, a newly registered active ingredient, was second in importance, with bentazon third. Imazethapyr controls a variety of broadleaf and grass weeds and may be applied preplant, preemergence, or postemergence. Its mode of action involves uptake by weed roots and/or foliage. Therefore, it controls existing weeds as well as germinating weeds. Bentazon is applied postemergence and controls many broadleaf weeds including cocklebur, jimsonweed, and velvetleaf. It may be used in combination with other broadleaf and/or grass herbicides to broaden the control spectrum.

Trifluralin, applied as a single active ingredient, was the most commonly used material in the southern region, accounting for 16 percent of the acre-treatments. Imazaquin, a broadleaf herbicide, was second in importance (7 percent) and can be applied preplant, preemergence, or postemergence. Thirteen other active ingredients were applied alone, with none garnering more than 5 percent of the acre-treatments. Several combination mixes were used but none dominated.

Cotton

Herbicides were used on 94 percent of the cotton acreage in 1990, ranging from 100 percent in Louisiana and Mississippi to 86 percent in California (table 20). On average, cotton farmers applied 2.1 herbicide treatments per acre. Treatment frequency ranged from 3.6 to 4.1 in the Delta States to 1.3 in California and Texas. The severe weed pressure in the Delta is demonstrated by the large proportion of the cotton acreage receiving 3 or more herbicide treatments per season. In Texas and the irrigated West, 1 or 2 herbicide treatments are the norm.

Of the herbicides applied as single ingredients, trifluralin was the most commonly used (29 percent). Fluometuron was used extensively in the Delta and pendimethalin and prometryn in Texas and the West, indicating varying weed problems among regions. Combination mixes accounted for 27 percent of the acre-treatments, but no single combination accounted for more than 4 percent. MSMA was included in many of the combination mixes and was applied as a

Table 20--Selected herbicides used in cotton production, 1990

Item	AR	LA	MS	TX	AZ	CA	Area
1,000 acres planted 1/	760	780	1200	5600	340	1050	9730
1,000 acres treated with herbicides	736	780	1200	5203	314	903	9136
Percent of acres treated:	97	100	100	93	92	86	94
With 1 treatment	11	2	6	65	47	59	48
With 2 treatments	19	14	11	26	37	26	23
With 3 treatments	19	22	20	2	5	1	7
With 4 treatments	18	43	28	0	3	0	8
With 5 treatments	17	13	20	0	0	0	5
With 6 or more	13	6	15	0	0	0	3
Average acre-treatments	3.62	3.69	4.08	1.30	1.59	1.32	2.07
1,000 acre-treatments	2664	2881	4896	6774	499	1190	18904
Acre-treatments by active ingredient: 2/				Percent			
Single materials--							
Cyanazine	9	4	[illegible]	nr	6	16	5
Diuron	2	5	3	2	1	nr	3
DSMA	2	2	2	*	nr	nr	1
Fluazifop-P-butyl	1	1	1	1	2	1	1
Fluometuron	23	17	17	1	2	nr	11
Methazole	2	2	2	*	nr	nr	1
MSMA	3	5	2	*	nr	nr	2
Norflurazon	5	3	4	*	nr	nr	2
Pendimethalin	2	2	2	11	22	24	7
Prometryn	5	5	3	13	15	9	8
Trifluralin	3	8	8	63	12	37	29
Other	1	4	2	2	3	8	3
Combination mixes--							
Cyanazine + MSMA	9	5	7	nr	1	nr	4
Fluometuron + MSMA	4	4	6	nr	nr	nr	3
Fluometuron + norflurazon	2	4	5	nr	nr	nr	2
Methazole + MSMA	5	1	1	nr	nr	nr	1
Norflurazon + pendimethalin	5	2	3	1	nr	nr	2
Prometryn + MSMA	5	7	7	nr	2	nr	3
Trifluralin + norflurazon	6	4	7	nr	nr	nr	3
Trifluralin + prometryn	nr	nr	nr	*	22	3	1
Other 2-way mixes	6	12	10	4	12	1	7
3-way mixes	2	3	2	nr	nr	nr	1
Total	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent.

1/ Preliminary. 2/ Spot treatments not included.

postemergence directed spray. With directed sprays, drop nozzles are used to place the herbicide material under the leaf canopy in the crop row.

Wheat

Herbicides were used on 34 percent of the winter wheat acreage in the surveyed States in 1990 (table 21). Washington and Montana treated over 80 percent of the winter wheat acreage with herbicides while in the Corn Belt it ranged from 10 to 20 percent. In Washington, winter annual broadleaf and grass weeds are a problem and must be controlled during mild portions of the winter. In Montana winterkill thins wheat stands and invading weeds must be controlled to prevent additional yield losses.

Chlorsulfuron and 2,4-D were the two most commonly used herbicides. Chlorsulfuron, registered in 1982, controls broadleaf and grass weeds and can be applied either pre- or postemergence. In contrast, 2,4-D controls only broadleaf weeds and is applied postemergence. Chlorsulfuron gained rapidly in popularity and by 1988 accounted for 49 percent of the herbicide acre-treatments in winter wheat production but by 1990 dropped to 23 percent. The reason for the drop is that weeds resistant to chlorsulfuron have been identified, kochia and Russian thistle, and farmers have been urged to rotate chlorsulfuron with other herbicide materials to slow the development of resistance in other weed species.

In States producing spring wheat and durum, herbicide use ranged from a low of 77 percent in South Dakota to a high of 99 percent in Minnesota (table 22). Generally spring wheat growers apply herbicides once, but in Minnesota and North Dakota about 20 percent of the acreage received 2 treatments. In durum wheat production over one-third of the acreage in North Dakota received 2 herbicide treatments. The number of treatments for effective weed control decreases from East to West because weeds are more of a problem in higher rainfall areas.

The most commonly used herbicides on both crops were 2,4-D, MCPA, and a combination of 2,4-D + dicamba. These materials are applied postemergence and control a wide range of broadleaf weeds. Trifluralin was used extensively in durum wheat production for foxtail control.

Table 21--Selected herbicides used in winter wheat production, 1990

Item	AR	CO	IL	KS	MO	MT	NE	OH	OK	SD	TX	WA	Area
1,000 acres harvested 1/	1300	2550	1950	11800	2000	2600	2250	1350	6300	1700	4200	2200	40200
1,000 acres treated with herbicides	317	627	342	2890	167	2159	1101	131	1769	869	1250	1858	13480
Percent of acres treated:	24	25	18	24	8	83	49	10	28	51	30	84	34
With 1 treatment	24	23	16	22	8	73	45	10	28	49	28	74	31
With 2 or more	0	2	2	2	0	10	4	0	0	2	2	10	3
Average acre-treatments	1.00	1.10	1.05	1.07	1.00	1.13	1.08	1.00	1.00	1.03	1.06	1.12	1.07
1,000 acre-treatments	317	690	359	3090	167	2432	1185	131	1769	893	1320	2090	14443
Acre-treatments by active ingredient: 2/						Percent							
Single materials--													
2,4-D	43	41	nr	15	16	30	58	57	4	16	19	19	23
Chlorsulfuron	nr	5	nr	51	nr	nr	nr	nr	83	5	12	nr	23
Dicamba	nr	nr	nr	5	nr	1	7	nr	nr	nr	1	1	2
MCPA	nr	nr	nr	1	nr	1	nr	43	2	nr	4	4	2
Metsulfuron	nr	18	nr	1	nr	10	7	nr	nr	22	4	nr	5
Other	6	nr	4	1	20	6	2	nr	nr	5	4	11	4
Combination mixes--													
2,4-D + chlorsulfuron	nr	nr	nr	15	nr	6	nr	nr	4	nr	nr	nr	5
2,4-D + dicamba	nr	9	nr	3	nr	15	5	nr	nr	8	2	1	5
2,4-D + glyphosate	nr	nr	nr	1	nr	nr	2	nr	nr	3	4	1	1
2,4-D + metsulfuron	nr	20	nr	nr	nr	18	16	nr	nr	32	4	nr	8
Dicamba + metsulfuron	nr	nr	nr	1	nr	1	nr	nr	nr	nr	45	nr	5
Thifensulfuron + tribenuron	51	5	96	nr	48	nr	nr	nr	nr	3	nr	1	5
Other 2-way mixes	nr	4	nr	3	nr	10	2	nr	7	3	2	14	6
3-way mixes	nr	nr	nr	3	16	1	nr	nr	nr	3	nr	48	[illegible]
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

nr = None reported.

1/ Preliminary. 2/ Spot treatments not included.

Table 22--Selected herbicides used in spring wheat production, 1990

Item	Spring wheat					Durum
	MN	MT	ND	SD	Area	ND
1,000 acres planted 1/	2800	2800	8000	2200	15800	3100
1,000 acres treated with herbicides	2761	2450	7402	1692	14305	2814
Percent of acres treated:	99	88	93	77	91	91
With 1 treatment	78	85	71	71	76	51
With 2 treatments	21	3	18	6	14	36
With 3 or more	0	0	4	0	1	2
Average acre-treatments	1.21	1.04	1.28	1.08	1.20	1.45
1,000 acre-treatments	3352	2538	9495	1819	17204	4078
Acre-treatments by active ingredient: 2/						
Single materials--						
2,4-D	20	28	24	19	23	18
Chlorsulfuron	1	3	nr	nr	1	nr
Dicamba	nr	nr	2	7	2	2
Diclofop-methyl	nr	nr	3	2	2	2
Difenzoquat	1	nr	2	nr	1	nr
Imidazolinone	*	2	1	nr	1	1
MCPA	14	nr	12	12	10	14
Metsulfuron	nr	3	nr	5	1	1
Triallate	7	2	2	nr	3	4
Tribenuron	nr	nr	3	nr	2	nr
Trifluralin	4	nr	6	2	4	19
Other	1	nr	1	7	1	1
Combination mixes--						
2,4-D + chlorsulfuron	nr	[illegible]	1	nr	2	nr
2,4-D + clopyralid	4	nr	1	5	2	nr
2,4-D + dicamba	2	21	13	12	12	11
2,4-D + metsulfuron	nr	24	2	2	5	6
2,4-D + tribenuron	nr	nr	2	2	1	2
MCPA + bromoxynil	15	nr	3	5	5	2
MCPA + chlorsulfuron	nr	2	2	nr	1	nr
MCPA + dicamba	5	3	6	7	5	6
Thifensulfuron + tribenuron	2	nr	3	5	3	1
Triallate + trifluralin	1	nr	2	nr	1	5
Other 2-way mixes	11	3	5	5	6	6
2,4-D + thifensulfuron + tribenuron	nr	nr	1	2	1	1
MCPA + thifensulfuron + tribenuron	2	nr	1	2	1	1
Fenoxaprop-ethyl + 2,4-D + MCPA	1	nr	4	nr	2	nr
Other 3 way-mixes	[illegible]	nr	1	nr	2	1
Total	100	100	100	100	100	100

nr = None reported.

1/ Preliminary. 2/ Spot treatments not included.

Regulatory Issues

Current pesticide regulatory concerns are focused on food safety, water quality, and avian mortality. Fungicides used on fruits and vegetables constitute a major food safety concern.

In 1989, the Environmental Protection agency (EPA) proposed canceling the registrations of EBDC fungicides (maneb, mancozeb, metiram, and zineb) for use on 45 of 55 fruit and vegetable crops representing 90 percent of current use. In September of that year, the leading manufacturers voluntarily suspended EBDC registrations for 42 of the 45 crops. The three remaining uses at issue were tomatoes, potatoes, and bananas. EPA's preliminary determination proposes canceling these three uses while leaving registrations in effect for almonds, asparagus, cranberries, figs, grapes, onions, peanuts, sugarbeets, sweet corn, and wheat.

In October 1990, EPA proposed canceling all granular formulations of carbofuran (a soil insecticide and nematicide), because of their association with avian mortality. This pesticide is used mainly on corn, sorghum, rice, and peanuts, but it is also important in the production of some fruit and vegetable crops.

Groundwater contamination is the major issue in EPA's review of the insecticide aldicarb, and the herbicide alachlor. Aldicarb is used in cotton, peanut, potato, and tobacco production; alachlor is important in corn and soybean production.

Tillage Systems

Tillage systems and the amount of previous crop residue remaining after planting are important indicators of soil erosion potential. The conservation compliance provisions of the 1985 Food Security Act (FSA) require farmers by 1995 to protect highly erodible land (HEL) through the implementation of conservation practices, or become ineligible for farm program benefits. The FSA states that a field designated as HEL must have a conservation plan approved by 1990 and that the plan must be fully implemented by 1995. To meet these requirements, a change in crop rotation, a change in tillage system, the addition of a conservation practice (such as contouring), and/or the installation of permanent structures (such as terraces) may be recommended. In many situations, changing tillage systems may be all that is needed.

The tillage system employed influences the types and levels of other input use. Labor and fuel inputs are reduced by tillage systems that require fewer trips over the field. On the other hand, a no-till system planting into alfalfa, grass, or a cover crop may include an extra herbicide application to kill the vegetation; in addition, increased fertilizer levels are sometimes recommended.

For erosion control purposes, a conservation tillage system is defined as one that leaves 30 percent or more of the soil surface covered with residue after planting. Less than 30 percent of the 1990 crop acreage surveyed meets this criterion, a statistic that may have implications for the amount of land that would currently meet conservation compliance restrictions. Producers farming HEL acres that don't currently meet the 30-percent residue level may have to change their tillage systems or risk losing farm program benefits.

Tillage system designations for 1990 were determined from estimates of residue remaining after planting. The percent of residue remaining was estimated from the level of previous crop residue and the incorporation rates of the tillage implements. For this report, the percent of residue remaining after planting was assumed to be evenly distributed over the soil surface.

Different tillage systems leave significantly different residue levels. Therefore, the type of tillage system directly affects erosion potential and water quality. In general, conventional tillage systems without the moldboard plow leave less than one-half as much residue after planting as mulch-till systems. Time spent in tilling the soil is related to the number of times the farmer goes over the field, as well as to implement size and tractor speed. For example, under conventional tillage without a moldboard plow, the number of passes over the field varies from an average of 3.4 for corn to 6.2 for cotton, compared with 3.8 for corn and 6.6 for cotton with the moldboard plow. Less tillage time permits fuel and labor savings.

Of the acreage planted to the major crops, currently less than 25 percent is tilled with a moldboard plow, which leaves about 2 percent of the residue from the previous crop. A no-till system is used on 12 percent or less, depending on the crop. Most of the acreage is cropped with conventional tillage without the moldboard plow, a system that leaves less than 30 percent residue on the soil surface after planting.

Corn

Tillage systems used in 1988, 1989, and 1990 corn production in the 10 major producing States appear to indicate a trend toward the use of conservation tillage systems (table 23). A corresponding increase is indicated in the average percent of soil surface covered with residue. At the same time, a corresponding decrease is indicated in the numbers of hours per acre and times over the field for tillage operations.

Tillage systems varied greatly among the 10 major producing States (table 24). Wisconsin had the highest use of the moldboard plow—50 percent—to accommodate the corn/alfalfa rotations needed to support dairy farming. This was down from 64 percent in 1989. In Nebraska, the moldboard plow was used on only about 5 percent of the corn acres.

Table 23--Tillage systems used in corn production, 1988, 1989, 1990

Category	1988	1989	1990 1/
Planted acres (1,000)	53,200	57,900	58,800
	Percent of acres 2/		
Tillage:			
Conv/w mbd plow 3/	20	19	17
Conv/wo mbd plow 4/	60	59	57
Mulch-till 5/	14	17	18
No-till 6/	7	5	9
Residue remaining after planting:	Percent of soil surface covered		
Conv/w mbd plow	2	2	2
Conv/wo mbd plow	16	16	16
Mulch-till	38	38	38
No-till	60	64	64
Average	19	19	22
	Number		
Hours per acre:			
Conv/w mbd plow	.8	.7	.7
Conv/wo mbd plow	.4	.4	.4
Mulch-till	.3	.3	.3
No-till	.1	.2	.2
Average	.5	.5	.4
Times over field:			
Conv/w mbd plow	4.0	4.1	3.8
Conv/wo mbd plow	3.5	3.5	3.4
Mulch-till	2.6	2.7	2.6
No-till	1.0	1.3	1.1
Average	3.3	3.4	3.1

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use [illegible] moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not [illegible] no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting, allows passes of nontillage implements, such as stalk choppers.

Nebraska does not have a preponderance of wet/heavy soils which require fall plowing. Furthermore, it has a more serious wind erosion problem than the other corn producing States.

Among the 10 States, a moldboard plow was used on 17 percent of the 1990 corn acres, and no-till systems were used on 9 percent. At 15 to 18 percent, Nebraska, Ohio, and Missouri had the highest proportion of acres under no-till, a figure that may reflect increased concern with erosion and related environmental effects. Missouri and Nebraska had the highest average residue levels, due to the prevalence of tillage systems without the moldboard plow. The residue coverage was similar across all States.

Soybeans

Soybean production also indicates a trend toward conservation tillage systems (tables 25 and 26). The 14 major soybean producing States were divided into the northern and southern areas. The northern area reported 23 percent of its acres using conventional tillage with a moldboard plow in 1990, compared with only 4 percent in the southern area. In contrast, 78 percent of southern area acreage used conventional tillage without the moldboard plow, compared with 51 percent of the northern area. Mulch tillage was more predominant in the northern than the southern area (21 vs. 7 percent), while no-till acreage was more prevalent in the southern area (12 vs. 6 percent).

Table 24-Tillage systems used in corn production, 1990

Category	IL	IN	IA	MI	[illegible]	MO	NE 1/	NE 2/	OH	SD	WI	Area
Planted acres (1,000) 3/	10,700	5,600	12,800	2,400	6,700	2,100	2,395	5,305	3,700	3,400	3,700	58,800
					Percent of acres 4/							
Tillage system:												
Conv/w mbd plow 5/	[illegible]	15	13	37	24	6	5	2	31	12	50	17
Conv/wo mbd plow 6/	68	59	59	49	56	37	55	64	39	61	39	57
Mulch-till 7/	14	14	22	8	16	43	22	19	14	25	8	18
No-till 8/	9	11	5	7	3	15	18	15	15	3	3	9
Residue remaining after planting:					Percent of soil surface covered							
Conv/w mbd plow	2	2	2	2	2	2	3	2	2	3	2	2
Conv/wo mbd plow	14	16	18	17	15	19	18	16	17	18	19	16
Mulch-till	38	37	38	36	35	41	40	38	39	40	41	38
No-till	66	68	65	73	52	67	61	60	64	id	id	64
Average	22	23	23	17	16	35	30	26	23	23	14	22
						Number						
Hours per acre:												
Conv/w mbd plow	.5	.9	.6	.9	.6	.7	.5	.5	[illegible]	.5	.9	.7
Conv/wo mbd plow	.4	.4	.4	.5	.4	.5	.4	.4	.5	.4	.7	.4
Mulch-till	.3	.3	.3	.3	.3	.2	.3	.3	.4	.3	.4	.3
No-till	.1	.2	.1	.1	.2	.1	.1	.2	.2	id	id	.2
Average	.4	.4	.4	.6	.4	.4	.3	.4	.5	.4	.8	.4
Times over field:												
Conv/w mbd plow	3.6	4.0	3.9	3.6	4.0	4.0	3.0	3.3	3.9	3.2	3.9	3.8
Conv/wo mbd plow	3.5	3.4	3.2	3.6	3.6	3.5	3.1	3.5	3.3	3.1	3.7	3.4
Mulch-till	2.5	2.7	2.4	3.2	2.7	2.4	2.5	2.9	2.7	2.5	2.8	2.6
No-till	1.0	1.1	1.1	1.0	1.5	1.0	1.0	1.5	1.0	id	id	1.1
Average	3.2	3.1	3.0	3.4	3.5	2.7	2.6	3.1	3.1	2.9	3.8	3.1

id = Insufficient data.

1/ Nonirrigated. 2/ Irrigated. 3/ Preliminary. 4/ May not add to 100 due to rounding. 5/ Conventional tillage with moldboard plow--any tillage system that includes the use of [illegible] moldboard plow and has less than 30 percent residue remaining after planting. 6/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use [illegible] moldboard plow. 7/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not [illegible] no-till system. 8/ No-tillage--no residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such [illegible] stalk choppers.

Table 25--Tillage systems used in northern soybean production, 1988, 1989, 1990

Category	1988	1989	1990 1/
Planted acres (1,000)	36,550	37,750	36,400
	Percent of acres 2/		
Tillage:			
Conv/w mbd plow 3/	28	26	23
Conv/wo mbd plow 4/	55	51	51
Mulch-till 5/	14	18	21
No-till 6/	3	4	6
Residue remaining after planting:	Percent of soil surface covered		
Conv/w mbd plow	2	2	2
Conv/wo mbd plow	17	17	17
Mulch-till	39	37	38
No-till	65	67	74
Average	17	19	19
	Number		
Hours per acre:			
Conv/w mbd plow	.7	.7	.6
Conv/wo mbd plow	.5	.5	.5
Mulch-till	.3	.4	.3
No-till	.1	.2	.2
Average	.5	.5	.5
Times over field:			
Conv/w mbd plow	4.2	4.3	4.2
Conv/wo mbd plow	4.0	4.1	4.1
Mulch-till	3.1	3.4	3.1
No-till	1.0	1.2	1.1
Average	3.8	3.9	3.7

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting, allows passes of nontillage implements, such as stalk choppers.

Table 26--Tillage systems used in southern soybean production, 1988, 1989, 1990

Category	1988	1989	1990 1/
Planted acres (1,000)	12,200	13,380	11,850
	Percent of acres 2/		
Tillage:			
Conv/w mbd plow 3/	3	4	4
Conv/wo mbd plow 4/	85	82	78
Mulch-till 5/	5	5	7
No-till 6/	7	10	12
Residue remaining after planting:	Percent of soil surface covered		
Conv/w mbd plow	2	2	1
Conv/wo mbd plow	[illegible]	13	10
Mulch-till	40	42	40
No-till	72	72	65
Average	14	15	19
	Number		
Hours per acre:			
Conv/w mbd plow	1.1	.8	1.0
Conv/wo mbd plow	.5	.6	.5
Mulch-till	.4	.3	.3
No-till	.2	.1	.2
Average	.5	.5	.5
Times over field:			
Conv/w mbd plow	4.1	4.3	4.3
Conv/wo mbd plow	4.6	4.8	4.4
Mulch-till	2.8	2.5	2.5
No-till	1.0	1.0	1.0
Average	4.3	4.3	3.8

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting, allows passes of nontillage implements, such as stalk choppers.

A reason for some of these differences may be found in the examination of rotation data. In the southern area, 50-90 percent of previous crop residue consisted of soybeans or a fallow period (leaving fragile and limited residues). In the northern area, over 60 percent of the previous crop residue was corn, which leaves a hardier and heavier residue.

In the northern area, Indiana and Ohio were the greatest users of no-till systems (table 27). In the southern area, Kentucky reported 36-percent usage of no-till (table 28). These States are recognized as leaders in the advocacy and adoption of no-till systems.

The residue remaining under conventional tillage was higher in the northern area. The machine labor hours per acre averaged 0.6 in the northern area and 1.0 in the southern area for conventional tillage with the moldboard plow, and the number of passes over the field were about the same. With mulch tillage, the northern area averaged nearly one more trip over the field than the southern area.

Spring and Durum Wheat

Tillage systems used in the production of spring and durum wheat indicate some variation over time, with shifts occurring between mulch and conventional tillage (table 29). This may be due to weather-soil relationships between years in these areas.

Much of the wheat grown in the Great Plains and the Western States is produced after a fallow period. Implement passes made during the fallow year were included in determining residue levels, hours per acre, and trips over the field. Normal fallow procedure for wheat in these States starts with chisel plowing and other noninversion tillage operations in the fall instead of a pass with the moldboard plow. For these States, therefore, the tables reflect more trips over the field under conventional tillage without the moldboard plow (table 30). North Dakota durum wheat acreage also shows this pattern because much of the durum wheat is planted after a fallow period.

Minnesota indicated greater use of the moldboard plow in spring wheat tillage operations (27 percent). This is because most spring wheat in Minnesota is produced on heavy clay soils in the Red River Valley.

Cotton

Nearly all cotton is produced using conventional tillage methods in the six major cotton States (table 31). However, use of the moldboard plow has decreased to half of the 1988 level.

Use of the moldboard plow was minimal in four of the States (table 32). The plow was used most extensively in Arizona (37 percent of the acreage) and Texas (21 percent). This was a decrease from 66 percent in 1989 for Arizona. Arizona,

Table 27--Tillage systems used in northern soybean production, 1990

Category	IL	IN	IA	MN	MO	NE	OH	Area
Planted acres (1000) 1/	9200	4300	8000	4600	4200	2400	3700	36400
	Percent of acres 2/							
Tillage system:								
Conv/w mbd plow 3/	20	32	16	46	2	id	39	23
Conv/wo mbd plow 4/	57	41	56	42	57	47	39	51
Mulch-till 5/	16	15	24	8	35	52	12	21
No-till 6/	6	11	3	3	6	nr	10	6
Residue remaining after planting:	Percent of soil surface covered							
Conv/w mbd plow	3	2	[illegible]	3	2	id	2	3
Conv/wo mbd plow	13	17	19	17	21	20	15	17
Mulch-till	39	38	39	40	41	37	38	39
No-till	64	67	70	51	64	nr	74	66
Average	18	21	23	13	30	29	19	19
	Number							
Hours per acre:								
Conv/w mbd plow	.6	.6	.6	.6	.8	id	.7	.6
Conv/wo mbd plow	.5	.5	.5	.5	.5	.5	.5	.5
Mulch-till	.4	.4	.3	.4	.3	.4	.5	.3
No-till	.1	.1	.1	.1	.1	nr	.3	.2
Average	.5	.5	.4	.5	.4	.4	.6	.5
Times over field:								
Conv/w mbd plow	4.3	3.9	4.2	4.4	3.3	id	3.9	4.2
Conv/wo mbd plow	4.4	3.6	4.2	4.6	3.5	3.7	3.9	4.1
Mulch-till	3.4	3.0	3.4	3.9	2.3	2.8	3.1	3.1
No-till	1.1	1.1	1.1	1.0	1.0	nr	1.0	1.1
Average	4.0	3.3	3.9	4.4	2.9	3.3	3.5	3.7

id = Insufficient data. nr = None reported.

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system.
6/ No-tillage--no residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

Table 28--Tillage systems used in southern soybean production, 1990

Category	AR	GA	KY	LA	MS	NC	TN	Area
Planted acres (1000) 1/	3100	900	1250	1800	2100	1400	1300	11850
	Percent of acres 2/							
Tillage system:								
Conv/w mbd plow 3/	1	11	5	nr	2	11	4	4
Conv/wo mbd plow 4/	85	69	53	94	78	65	78	78
Mulch-till 5/	9	16	5	2	10	4	4	7
No-till 6/	5	4	36	4	10	20	15	12
Residue remaining after planting:	Percent of soil surface covered							
Conv/w mbd plow	id	1	1	nr	2	1	1	1
Conv/wo mbd plow	13	10	16	6	10	9	9	10
Mulch-till	42	38	37	id	42	39	36	40
No-till	65	66	64	61	65	66	65	65
Average	18	16	34	9	19	21	18	19
	Number							
Hours per acre:								
Conv/w mbd plow	id	1.1	.9	nr	.8	1.3	.8	1.0
Conv/wo mbd plow	.4	.5	.5	.5	.5	.7	.6	.5
Mulch-till	.3	.4	.2	id	.3	.4	.4	.3
No-till	.1	.2	.2	.2	.1	.2	.2	.2
Average	.3	.5	.4	.5	.5	.7	.5	.5
Times over field:								
Conv/w mbd plow	id	4.4	4.1	nr	5.0	4.2	4.2	4.3
Conv/wo mbd plow	4.3	3.4	3.7	4.9	4.7	4.1	4.5	4.4
Mulch-till	2.6	2.4	2.0	id	2.5	2.0	3.2	2.5
No-till	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Average	4.0	3.2	2.7	4.7	4.1	3.4	3.9	3.8

id = Insufficient data. nr = None reported.

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system.
6/ No-tillage--no residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

Table 29--Tillage systems used in spring and durum wheat production, 1988, 1989, 1990 1/

Category	Spring Wheat 1988	Spring Wheat 1989	Spring Wheat 1990 2/	Durum Wheat 1988	Durum Wheat 1989	Durum Wheat 1990
Planted acres (1,000)	2,130	2,085	1,800	2,500	3,000	3,100
			Percent of acres 3/			
Tillage:						
Conv/w mbd plow 4/	16	9	12	5	4	4
Conv/wo mbd plow 5/	62	61	63	69	57	62
Mulch-till 6/	21	29	23	24	39	34
No-till 7/	1	1	3	2	1	id
			Percent of soil surface covered			
Residue remaining after planting:						
Conv/w mbd plow	2	2	2	3	2	3
Conv/wo mbd plow	12	16	16	14	16	17
Mulch-till	39	40	39	39	43	42
No-till	63	id	64	72	id	id
Average	17	22	21	21	21	25
			Number			
Hours per acre:						
Conv/w mbd plow	.5	.5	.5	.3	.3	.3
Conv/wo mbd plow	.4	.4	.3	.4	.4	.3
Mulch-till	.3	.2	.2	.2	.2	.2
No-till	.1	id	.1	.1	id	id
Average	.4	.3	.3	.3	.3	.3
Times over field:						
Conv/w mbd plow	4.7	3.3	3.7	3.0	4.2	2.6
Conv/wo mbd plow	4.4	4.1	4.1	5.2	5.0	4.5
Mulch-till	3.1	2.8	2.7	2.9	2.8	3.0
No-till	1.0	id	1.0	1.0	id	id
Average	4.1	3.6	3.7	4.5	4.1	3.9

id = Insufficient data.

1/ Preliminary. 2/ Idaho not included in 1990. 3/ May not add to 100 due to rounding. 4/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 5/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 6/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 7/ No-tillage--no residue-incorporating tillage operations performed prior to planting, allows passes of nontillage implements, such as stalk choppers.

Table 30--Tillage systems used in spring and durum wheat production, 1990

Category	Spring wheat MN	Spring wheat MT	Spring wheat ND	Spring wheat SD	Spring wheat Area	Durum wheat ND
Planted acres (1,000) 1/	2,800	2,800	8,000	2,200	15,800	3,100
			Percent of acres 2/			
Tillage system:						
Conv/w mbd plow 3/	27	5	9	10	12	4
Conv/wo mbd plow 4/	55	70	65	56	63	62
Mulch-till 5/	17	20	24	31	23	34
No-till 6/	1	5	2	4	3	id
			Percent of soil surface covered			
Residue remaining after planting:						
Conv/w mbd plow	2	1	3	2	2	3
Conv/wo mbd plow	14	18	15	16	16	17
Mulch-till	35	41	40	38	39	42
No-till	id	id	id	id	64	id
Average	15	24	21	24	21	25
			Number			
Hours per acre:						
Conv/w mbd plow	.7	.6	.4	.4	.5	.3
Conv/wo mbd plow	.4	.4	.3	.3	.3	.3
Mulch-till	.3	.3	.2	.2	.2	.2
No-till	id	id	id	id	.1	id
Average	.4	.4	.3	.3	.3	.3
Times over field:						
Conv/w mbd plow	4.6	5.0	3.2	1.8	3.7	2.6
Conv/wo mbd plow	4.1	4.7	4.1	3.2	4.1	4.5
Mulch-till	3.0	3.5	2.5	2.4	2.7	3.0
No-till	id	id	id	id	1.0	id
Average	4.0	4.3	3.6	2.7	3.7	3.9

id = Insufficient data.

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

Table 31--Tillage systems used in cotton production, 1988, 1989, 1990

Category	1988	1989	1990 1/
Planted acres (1,000)	9,700	8,444	9,730
		Percent of acres 2/	
Tillage:			
Conv/w mbd plow 3/	28	15	14
Conv/wo mbd plow 4/	72	84	[illegible]
Mulch-till 5/	id	id	1
No-till 6/	id	id	1
Residue remaining after planting:		Percent of soil surface covered	
Conv/w mbd plow	0	0	0
Conv/wo mbd plow	3	3	3
Mulch-till	id	id	51
No-till	id	id	63
Average	2	2	3
		Number	
Hours per acre:			
Conv/w mbd plow	.8	.9	.8
Conv/wo mbd plow	.7	.7	.7
Mulch-till	id	id	.3
No-till	id	id	.1
Average	.8	.8	.7
Times over field:			
Conv/w mbd plow	6.2	7.2	6.6
Conv/wo mbd plow	6.1	6.4	6.2
Mulch-till	id	id	2.8
No-till	id	id	1.0
Average	6.1	6.5	6.2

id = Insufficient data.

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting, allows passes of nontillage implements, such as stalk choppers.

Table 32--Tillage systems used in cotton production, 1990

Category	AZ	AR	CA	LA	MS	TX	Area
Planted acres (1,000) 1/	340	760	1,050	780	1,200	5,600	9,730
			Percent of acres 2/				
Tillage system:							
Conv/w mbd plow 3/	37	5	4	nr	1	21	14
Conv/wo mbd plow 4/	62	94	93	99	99	77	84
Mulch-till 5/	1	nr	2	1	nr	1	1
No-till 6/	nr	1	2	nr	nr	1	1
Residue remaining after planting:			Percent of soil surface covered				
Conv/w mbd plow	0	0	0	nr	id	0	0
Conv/wo mbd plow	2	2	2	2	1	4	3
Mulch-till	id	nr	41	id	nr	57	51
No-till	nr	id	12	nr	nr	78	63
Average	2	3	3	2	1	4	3
				Number			
Hours per acre:							
Conv/w mbd plow	1.3	.9	1.3	nr	id	.8	.8
Conv/wo mbd plow	.8	.6	1.0	.7	.8	.6	.7
Mulch-till	id	nr	.4	id	nr	.3	.3
No-till	nr	id	.2	nr	nr	.1	.1
Average	1.0	.6	1.0	.7	.8	.6	.7
Times over field:							
Conv/w mbd plow	8.0	6.8	9.4	nr	id	6.4	6.6
Conv/wo mbd plow	6.6	6.2	7.3	6.6	7.0	5.7	6.2
Mulch-till	id	nr	3.0	id	nr	3.3	2.8
No-till	nr	id	1.0	nr	nr	1.0	1.0
Average	7.1	6.2	7.1	6.6	7.0	5.8	6.2

id = Insufficient data. nr = None reported.

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

California, and parts of Texas have State "plow-down" laws requiring that the cotton plant be disposed of to eliminate the food source for bollworms and boll weevils. Some producers have misinterpreted these laws to mean that the previous crop must be plowed with a moldboard plow. California producers mainly use multiple passes with a heavy disk. In some areas of Texas, the moldboard plow is also used to bring up subsoil clay to cover the soil surface with clods, which helps control wind erosion.

The large number of tillage trips across the field (averaging 6.2) leaves very little residue, even without use of the moldboard plow. Research is being conducted in a number of cotton producing States on the use of mulch-till and no-till systems and the use of cover crops.

Rice

Heavy spring rains in 1990 delayed tillage and planting operations in the South Central States. This caused many farmers to reduce the number of tillage operations. This may account for some of the increase in conservation tillage systems reported in 1990 rice production (table 33).

Table 33--Tillage systems used in rice production,1988, 1989, 1990

Category	1988	1989	1990 1/2/
Planted acres (1,000)	2,130	2,085	1,800
		Percent of acres 3/	
Tillage:			
Conv/w mbd plow 4/	2	1	1
Conv/wo mbd plow 5/	96	97	96
Mulch-till 6/	2	id	3
No-till 7/	id	id	1
Residue remaining after planting:	Percent of soil surface covered		
Conv/w mbd plow	0	0	id
Conv/wo mbd plow	2	3	4
Mulch-till	41	id	46
No-till	id	id	45
Average	4	4	13
		Number	
Hours per acre:			
Conv/w mbd plow	id	id	id
Conv/wo mbd plow	.7	.5	.5
Mulch-till	.3	id	.3
No-till	id	id	.1
Average	.6	.5	.5
Times over field:			
Conv/w mbd plow	id	6.4	id
Conv/wo mbd plow	6.0	6.0	5.9
Mulch-till	3.5	id	2.7
No-till	id	id	1.0
Average	5.9	6.0	5.8

id = Insufficient data.

1/ Preliminary. 2/ California not included in 1990. 3/ May not add to 100 due to rounding. 4/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 5/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow.
6/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system.
7/ No-tillage--no residue-incorporating tillage operations performed prior to planting, allows passes of nontillage implements, such as stalk choppers.

Most of the rice acreage in Arkansas and Louisiana is produced under conventional tillage without the moldboard plow (table 34). Arkansas reported 3 percent mulch-till in 1990 compared to less than 1 percent in 1989. Erosion is not a problem in rice production because most rice is planted on flat, heavy-textured soils which are flooded. Rice seedbeds usually are nearly residue-free, partly because residue is perceived to harbor the disease organism that causes stem rot at the water line.

Winter Wheat

Tillage practices reported in 1988, 1989, and 1990 winter wheat production indicated a reduction in the use of the moldboard plow and an increase in conservation tillage (table 35). Detailed data for 1990 were presented in *Agricultural Resources: Inputs, Situation and Outlook Report* (USDA, Economic Research Service, AR-20, October 1990).

Table 34--Tillage systems used in rice production, 1990

Category	AR	LA	Area
Planted acres (1,000) 1/	1,230	570	1,800
	Percent of acres 2/		
Tillage system:			
Conv/w mbd plow 3/	id	1	1
Conv/wo mbd plow 4/	95	97	96
Mulch-till 5/	3	id	3
No-till 6/	1	1	1
Residue remaining after planting:	Percent of soil surface covered		
Conv/w mbd plow	id	id	id
Conv/wo mbd plow	4	3	4
Mulch-till	45	id	46
No-till	52	id	45
Average	16	5	13
		Number	
Hours per acre:			
Conv/w mbd plow	id	id	id
Conv/wo mbd plow	.5	.5	.5
Mulch-till	.3	id	.3
No-till	.1	id	.1
Average	.5	.5	.5
Times over field:			
Conv/w mbd plow	id	id	id
Conv/wo mbd plow	6.0	5.8	5.9
Mulch-till	2.6	id	2.7
No-till	1.0	id	1.0
Average	5.8	5.7	5.8

id = Insufficient data.

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting.
4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow.
5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

Table 35--Tillage systems used in winter wheat production, 1988, 1989, 1990

Category	1988	1989	1990 1/
Planted acres (1,000)	32,830	34,710	40,200
		Percent of acres 2/	
Tillage:			
Conv/w mbd plow 3/	15	16	12
Conv/wo mbd plow 4/	67	68	69
Mulch-till 5/	16	15	17
No-till 6/	1	1	3
Residue remaining after planting:		Percent of soil surface covered	
Conv/w mbd plow	2	2	2
Conv/wo mbd plow	14	14	14
Mulch-till	38	35	38
No-till	61	66	53
Average	17	17	18
		Number	
Hours per acre:			
Conv/w mbd plow	.7	.7	.7
Conv/wo mbd plow	.5	.5	.5
Mulch-till	.4	.4	.3
No-till	.1	.1	.1
Average	.5	.5	.5
Times over field:			
Conv/w mbd plow	5.3	5.3	5.3
Conv/wo mbd plow	5.0	4.8	5.0
Mulch-till	4.5	4.1	4.0
No-till	1.0	1.0	1.0
Average	4.9	4.7	4.7

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting, allows passes of nontillage implements, such as stalk choppers.

Highly Erodible Land

The largest acreage of 1990 highly erodible land was used for corn production in the surveyed States, although winter wheat had a higher percentage of crop acres designated as HEL (table 36).

With the exception of southern soybeans (54 percent), more than 60 percent of the 1990 cropland designated HEL in each of the surveyed States utilized conventional tillage methods. This figure decreased slightly from 1989 and should continue to decline over the next few years, as approved conservation plans are implemented.

Energy

The crisis in the Persian Gulf has played havoc with the world market for crude oil. The situation has translated into a great deal of volatility in the price of crude oil, which in turn has generated considerable uncertainty about the prices farmers will pay for refined petroleum products in the future. The pre-embargo estimate of the 1991 world price of crude oil (i.e., before the United Nations-sanctioned trade embargo of Iraq) was about $20 per barrel. Over the past 6 months, the world price has fluctuated between this amount and more than twice this figure.

If the world price of crude oil for 1991 averages about $30 per barrel, as assumed in an analysis by the U.S. Department of Energy (DOE), farm expenses for diesel fuel, gasoline, liquefied petroleum gas, and electricity will rise by approximately 13 percent over projections based on the pre-embargo

Table 36--Erodibility distribution of crop acreage and tillage systems, 1990

Category	Winter wheat 1/	Corn	Northern soybeans	Southern soybeans	Cotton	Spring wheat	Durum wheat	Rice
Planted acres (1,000) 2/	40,200	58,800	36,400	11,850	9,730	15,800	3,100	1,800
Highly erodible land (%)	29	22	20	10	22	15	3	2
Land not highly erodible (%)	64	74	75	77	71	76	81	88
Land not designated (%)	7	[illegible]	5	13	7	9	16	10
Highly erodible land:								
Planted acres (1,000) 2/	11,610	12,700	7,180	1,160	2,100	2,390	95	40
				Percent				
Tillage system:								
Conv/w mbd plow 3/	[illegible]	12	10	6	22	[illegible]	50	nr
Conv/wo mbd plow 4/	68	56	57	48	77	59	50	100
Mulch-till 5/	20	20	28	6	id	32	nr	nr
No-till 6/	3	11	6	40	id	6	nr	nr
Land not highly erodible:								
Planted acres (1,000) 2/	25,660	43,230	27,450	9,160	6,930	12,010	2,505	1,590
				Percent				
Tillage system:								
Conv/w mbd plow 3/	13	[illegible]	26	[illegible]	10	13	3	[illegible]
Conv/wo mbd plow 4/	70	57	49	80	88	64	62	96
Mulch-till 5/	15	18	20	8	1	21	34	3
No-till 6/	2	8	[illegible]	9	1	[illegible]	[illegible]	1
Land not designated:								
Planted acres (1,000) 2/	2,930	2,870	1,770	1,530	700	1,400	500	170
				Percent				
Tillage system:								
Conv/w mbd plow 3/	19	21	25	5	27	16	nr	nr
Conv/wo mbd plow 4/	64	57	54	[illegible]	72	59	62	97
Mulch-till 5/	15	11	9	2	id	25	38	3
No-till 6/	3	10	11	7	nr	nr	nr	nr

id = Insufficient data. nr = None reported.

1/ Harvested acres for winter wheat only. 2/ Preliminary. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting; allows passes of nontillage implements, such as stalk choppers.

energy price estimate. (In 1989, expenditures on fuels accounted for approximately 3.6% of all farm production expenses.) A rise in the price of crude oil to an average of $40 per barrel would increase farm energy expenses by 25 percent.

The World Crude Oil Price

During the first half of 1990, the world crude oil price declined from a post-1985 high of more than $20 per barrel to $13 per barrel, a drop of 35 percent. The crude oil price, which had been buoyed by unusually cold winter, fell significantly in the early months of the year as the weather turned mild and production from the Organization of Petroleum Exporting Countries (OPEC) remained high. Moreover, the U.S. economy was experiencing a slowdown in growth resulting in declining demand and a sizable buildup of crude oil stocks.

Between June and late July of 1990, oil prices had begun to recover as OPEC members agreed to enforce their production quotas more aggressively. Iraq's invasion of Kuwait on August 2, 1990, resulted in further immediate and large price hikes as trade sanctions against Iraq were introduced. The immediate impact was an increase in the spot market world crude oil price to around $35 to $40 per barrel and a loss of combined Iraqi and Kuwaiti production of 4.3 million barrels per day. Almost all of this loss has been made up by the surge of production of other oil producing nations. Currently, spot crude oil is trading at $20-$25 per barrel.

Domestic Petroleum Consumption and Production

The U.S. Department of Energy (DOE) has produced an analysis of the consumption and production of refined petroleum products for 1991 (table 37). Given an assumed price of $30 per barrel and a sluggish economy, U.S. petroleum demand is expected to decline. The demand for all refined petroleum products in 1991 is expected to be 16.3 million barrels per day, a 4.3-percent decline from the previously projected 1991 level.

On the supply side, the rate of decline in domestic crude oil production in 1991 is expected to slow, but not reverse. If the average world price of crude oil rises above $30 per barrel, domestic production might even post an increase in 1991. This assumes that the oil industry perceives that a higher price of crude oil will be enduring enough to justify significant investment in drilling and development. Growth in crude oil imports is projected to reverse from an increase of 3.7 percent for 1990 to an 11.4-percent decline for 1991, largely as a result of reduced consumption. In 1991, net petroleum imports are projected to decline for the first time since 1985.

Unrelated to events in the Persian Gulf, motor gasoline retail prices are 5 cents per gallon higher than a year ago due to

Table 37--U.S. petroleum consumption-supply balance

Item	1987	1988	1989	1990	Forecast 1991
	Million barrels/day				
Consumption:					
Motor gasoline	7.21	7.34	7.33	7.25	7.03
Distillate fuel	2.98	3.12	3.16	3.01	2.90
Residual fuel	1.26	1.[illegible]	1.37	1.24	1.00
Other petroleum 1/	5.22	5.45	5.47	5.49	5.33
Total	16.67	17.29	17.33	16.99	16.26
	Million barrels/day				
Supply:					
Production 2/	10.65	10.51	9.91	9.52	9.46
Net crude oil and petroleum imports (includes SPR) 3/	5.91	6.59	7.20	7.47	6.62
Net stock withdrawals	0.04	0.19	0.21	-0.01	0.16
Total	16.60	17.29	17.32	16.98	16.24
	Percent				
Net imports as share of total supply	35.60	38.11	41.57	43.99	40.76
	Percent change from previous year				
Consumption		3.72	0.23	-1.96	-4.30
Domestic production		-1.31	-5.71	-3.94	-0.63
Imports		11.51	9.26	3.75	-11.38

1/ Includes crude oil product supplied, natural gas liquid (NGL), other hydrocarbons and alcohol, and jet fuel. 2/ Includes domestic oil production, NGL, and other domestic processing gains (i.e., volumetric gain in refinery cracking and distillation process). 3/ Includes both crude oil and refined products. SPR denotes the Strategic Petroleum Reserves.

Source: U.S. Department of Energy, Energy Information Administration. Short-Term Energy Outlook. DOE/EIA-0202(90/4Q). November 1990.

the increase in the excise tax on motor fuels associated with the Omnibus Budget Reconciliation Act of 1990 (H.R. 5835). Farmers, however, are exempt from this tax for all fuel used for on-farm purposes, and there should be little, if any, farm sector impacts from this tax hike.

The consumption of most refined petroleum products is expected to decline in 1991. In the transportation sector, slow economic growth and higher prices for gasoline and diesel fuel are expected to dampen travel demand. Growth in motor-vehicle-miles traveled is expected to be more than offset by the continued improvements in efficiency of gasoline and diesel fuel use. Higher fuel costs are expected to result in higher airline ticket prices, which in turn should keep commercial jet fuel demand weak in 1991. Jet fuel demand will probably increase in 1991 with a surge in military operations associated with Operation Desert Storm.

Higher energy prices are expected to have important effects on domestic production of crude oil in 1991. This will be especially true if oil producers perceive that higher prices will persist beyond the next few months. Domestic crude oil output is projected to decline in 1991 by 60,000 barrels per day from 1990 levels. This compares with an average decline of 390,000 barrels per day in 1990 over 1989 levels.

Net imports of crude oil are expected to decrease by 850,000 barrels per day to 6.62 million barrels per day in 1991, compared with an increase of 270,000 barrels per day in 1990. The expected 1991 decrease largely reflects the increase in the world price of crude oil and the resulting price-induced conservation effects.

End-of-year crude oil inventories are projected to remain almost unchanged in 1991. The sizable stock drawdown during the second half of 1990, brought about by the disruption of normal supply patterns, was offset by the unusual buildup of stocks during the first half of 1990.

Energy in the Farm Sector

The U.S. agricultural sector's energy supply and price expectations reflect world crude oil market conditions. As noted previously, current world crude oil supplies are adequate. This situation is expected to continue through 1991. If the price stabilizes at around $30 per barrel, the prices paid by farmers for various types of energy will be approximately 13 percent higher than they would have been had the $20-per-barrel pre-embargo world price been maintained.

Little shift is expected in the input mix (e.g., fuel choice) over the next year or so. In the intermediate- to long term, however, if a higher price of crude oil remains in effect, farmers will likely begin substituting relatively less expensive energy (e.g., natural gas) for refined petroleum products (e.g, diesel fuel and gasoline) when and where substitutions are feasible. If a price of $40 per barrel is realized, it is expected that the energy prices paid by farmers will be approximately 25 percent higher relative to the $20-per-barrel pre-embargo estimate .

Higher prices for energy inputs will have several impacts throughout the farm sector. If the world price of crude oil averages $30 per barrel, total farm production expenses for 1991 would rise by approximately 1 percent. Lower expenses for farm-origin inputs (e.g., feed, feeder livestock, and seed), due to an expected fall in the cost for feed and feeder livestock, will offset part of the rise in expenses for nonfarm-origin inputs (fuels and oil, electricity, fertilizer, and pesticides).

Additionally, if oil prices average $30 per barrel, net farm income is projected to fall 5.5 percent due to a reduction in cash receipts (mostly resulting from lower prices for livestock) coupled with the higher production expenses. Finally, the higher costs and lower net returns would encourage increased farmer participation in the agricultural commodity programs. If the world price of crude oil averages $30 per barrel for 1991, increased participation in the agricultural commodity programs is projected to cost the government an additional 0.6 percent over earlier estimates.

Farm Fuel Use

The combined consumption by agriculture of refined petroleum products, such as diesel fuel, gasoline, and liquefied petroleum gas, has declined steadily since 1978. Although the number of acres planted influences farm energy use, other factors, including weather, are also important. For example, the switch from gasoline to diesel-powered engines; conservation tillage practices; larger, multifunction machines; and innovations in crop drying and irrigation have contributed to this decline. While no-till and mulch-till farming practices have not yet been widely adopted, they are now as prevalent as conventional tillage practices in some parts of the United States.

With only a minimal increase in cropland acres planted and harvested in 1990, with few significant changes in cropping practices, and with somewhat higher average energy prices for the entire growing season, the data, when available (later in 1991), are expected to show that 1990 farm energy consumption remained near its level for 1989.

Energy Prices Rose in 1990; Projected Up Again in 1991

Crude oil prices (especially imported, as the marginal supply in most instances) heavily influence the prices farmers pay for refined petroleum products, such as diesel fuel and gasoline. In 1990, average nominal gasoline prices (i.e., inflation impact included) increased by 11 percent and nominal diesel fuel prices rose by 25 percent over 1989 levels (table 38). More revealing is the fact that the price of gasoline in October 1990 increased by 32 percent over its level a year earlier while the price of diesel fuel increased by 53 percent. These gains are attributable to refiners' higher costs of acquiring crude oil. A rise in average real energy prices (i.e., inflation effect netted out) is expected for 1991. The magnitude of the increase is a function of the turn of events in the Persian Gulf.

Higher Energy Expenditures for 1990

In 1989, farm energy expenditures for diesel fuel, gasoline, liquefied petroleum gas, natural gas, lubricants, and electricity totaled $6.78 billion, down 4.5 percent from a year earlier (table 39). This reduction reflects no change in fuel and lubricant expenditures and about a 12-percent decline in electricity expenditures. Higher energy prices, slightly higher yields, increased acres planted and harvested, and more normal weather conditions in 1989 over 1988 combined to account for the observed declines. For 1990, a gain in planted and harvested acreage and a slight increase in acres irrigated, coupled with higher refined petroleum product prices in the fourth quarter, are estimated to raise energy expenditures to $7.24 billion, nearly 7 percent above 1989's reduced level.

Table 38--Average U.S. farm fuel prices 1/

Year	Gasoline	Diesel	LP gas
	$/gallon 2/		
1981	1.29	1.16	0.70
1982	1.23	1.11	0.71
1983	1.18	1.00	0.77
1984	1.16	1.00	0.76
1985	1.15	0.97	0.73
1986	0.89	0.71	0.67
1987	0.92	0.71	0.59
1988	0.93	0.73	0.59
1989	1.05	0.76	0.58
1990	1.17	0.94	0.83
Oct 1989	1.07	0.80	0.58
Oct 1990	1.41	1.22	0.94

1/ Based on surveys of farm supply dealers conducted by the National Agricultural Statistics Service, USDA. 2/ Bulk delivered.

Table 39--Farm energy expenditures

Item	1987	1988	1989	Forecast 1990
	$ billion			
Fuels and lubricants:				
Gasoline	1.37	1.42	1.44	1.45
Diesel	2.13	2.12	2.12	2.20
LP gas	0.38	0.38	0.38	0.39
Other	0.47	0.53	0.51	0.55
Electricity:				
Excluding irrigation	2.03	2.17	1.69	2.00
For irrigation	0.43	0.48	0.64	0.65
Total	6.81	7.10	6.78	7.24
Percent change from preceding year		4.25	-4.51	6.78

Source: U.S. Department of Agriculture, National Agriculture Statistics Service, Farm Production Expenditures, 1987, 1988, 1989 Summaries.

Farm Machinery

Demand

Unit sales of tractors and other farm machinery rose in 1990, continuing a general trend begun in 1987 as farmers replaced aging equipment after several years of declining purchases. Sales increased 10 to 23 percent for two- and four-wheel-drive tractors in 1990, and 15 percent for combines. Sales of tractors and combines in 1990 continued strong through the first 7 months of the year. After weakening in August, September, and October, farm machinery sales finished the year with renewed strength. Moderate increases are forecast for tractors and farm machinery for 1991, averaging about 4 percent (table 40).

Several factors affected demand for farm machinery in 1990 (table 41). Positive factors included gains in net farm and net cash incomes. Interest expenses decreased about $1 billion. Exports of U.S. agricultural commodities were up slightly, and cash receipts were up nearly $8 billion from 1989 to 1990. While production expenses rose by $3 billion, the increase was not enough to cause a fall in net income. Acres idled by commodity programs and the Conservation Reserve Program were down slightly from 1989 to 1990, from 60.8 to 59.9 million acres.

Preliminary 1990 estimates show the value of farm real estate assets up by $22 billion from 1989. Nonreal estate assets were up by another $20 billion. Farm debt decreased by $2 billion. In addition, the previous 3 years showed substantial increases in assets and reductions in debt, exerting a positive impact on farmers' ability to borrow to finance farm machinery purchases.

The reduction in Government payments is probably the most significant negative influence on sales of farm machinery.

Table 40--Domestic farm machinery unit sales

Machinery category	1985	1986	1987	1988	1989	Preliminary 1990	Forecast 1991	Change 89-90	Change 90-91
	Units							Percent	
Tractors:									
Two-wheel-drive									
40-99 hp	37,800	30,800	30,700	33,200	34,900	38,400	39,200	10	2
100-139 hp 1/	7,300	5,100	5,100	4,300	5,200				
Over 139 hp 1/	10,400	9,100	10,800	11,800	15,400				
Total over 99 hp	17,700	14,300	15,900	16,100	20,600	22,800	23,200	11	2
Four-wheel-drive	2,900	2,000	1,700	2,700	4,200	5,100	5,500	23	[illegible]
Grain and forage harvesting equipment:									
Self-propelled combines	8,400	7,700	7,200	6,000	9,100	10,400	11,500	15	11
Forage harvesters 1/2/	2,500	2,200	2,300	2,400	2,800				
Haying equipment:									
Mower conditions 1/	11,200	10,900	11,200	11,000	13,200				

na = Not available.

1/ Discontinued after 1989. 2/ Shear bar type.

Source: Historical data are from the Equipment Manufacturers Institute (EMI). All 1991 values are ERS forecasts.

Table 41--Trends in U.S. farm investment expenditures and factors affecting farm investment demand

Item	1984	1985	1986	1987	1988	1989	Forecast 1990	Forecast 1991
				$ billion				
Capital expenditures:								
Tractors	2.54	1.94	1.51	2.10	2.41	2.85	2.9	2.4-3.0
Other farm machinery	4.68	3.23	3.09	4.26	4.03	5.09	5.2	5.0-5.4
Total	7.22	5.17	4.60	6.36	6.44	7.94	8.1	7.4-8.4
Tractor and machinery repairs	3.8	3.74	3.73	3.94	4.00	4.72	4.8	4.4-4.9
Trucks and autos	2.04	1.76	1.71	2.17	2.30	2.56	2.8	2.4-3.0
Farm buildings 1/	3.26	2.26	2.14	2.60	2.32	2.47	2.5	2.4-2.7
Factors affecting demand:								
Interest expenses	21.1	18.6	17.1	15.5	15.2	15.1	14	14-15
Total production expenses	143.8	131.9	125.5	127.7	132.1	142.6	145	149-154
Outstanding farm debt 2/ 3/	204	188	167	154	149	146	144	140-146
Farm real estate assets 2/	694	650	606	634	666	688	710	720-730
Farm nonreal estate assets 2/		234.6	235.0	253.3	272.7	284.1	295	290-305
Agricultural exports 4/	38.0	31.2	26.3	27.9	35.3	39.6	40	38.5
Net farm income	26.3	31.0	31.0	41.3	41.8	46.7	49	44-49
Net cash income	36.6	47.9	46.7	56.1	58.1	54.6	59	55-60
Direct Government payments	8.4	7.7	11.8	16.7	14.5	10.9	9	8-9
				Million acres				
Diverted acres 5/	27.0	30.7	48.1	76.2	77.7	60.8	59.9	na
				Percent				
Real prime rate 6/ 7/	8.3	6.9	5.7	5.0	6.0	6.8	5.9	na
Nominal farm machinery and equipment loan rate 8/	14.6	13.7	12.2	11.5	11.7	12.8	12.3	12.2
Real farm machinery and equipment loan rate 7/	10.8	10.7	9.4	8.3	8.4	8.7	8.2	na
Debt-asset ratio 9/	21.5	21.2	19.8	17.3	15.8	15.0	14	13-14

na = Not available.

1/ Includes service buildings, structures, and land improvements. 2/ Calculated using nominal dollar balance sheet data, including farm households for December 31 of each year. 3/ Excludes CCC loans. 4/ Fiscal year. 5/ Includes acres idled through commodity programs and acres enrolled in the Conservation Reserve Program. 6/ Monthly average. 7/ Deflated by the GNP Deflator. 8/ Average annual interest rate. From the quarterly sample survey of commercial banks: Agricultural Financial Databook, Board of Governors of the Federal Reserve System. Interest for 1991 is for first quarter. 9/ Outstanding farm debt (including households) divided by the sum of farm real and nonreal estate asset values.

Source: Agricultural Income and Finance, Situation and Outlook Report, AFO-39, ERS; and other ERS sources.

Estimated Government payments were down nearly $2 billion from 1989 to 1990. Government payments are forecast to be no higher in 1991 and may decrease. Government programs aimed at cutting crop surpluses through reducing planted acres, especially for wheat, may also decrease the demand for farm machinery.

Projecting the demand for farm machinery is complicated by the uncertain effect of the war in the Persian Gulf. Further, the downturn in the overall economy may affect the demand for farm machinery, although one argument holds that farmers have already had their recession during the early 1980's and have since reduced their debt burdens. Additional cuts in Government support programs could also reduce demand. Without the uncertainties of the war in the Middle East and the recent economic downturn, projected 1991 increases in demand would likely have been higher.

Farm Machinery Trade

The Department of Commerce increased its estimate of the value of 1990 exports of farm machinery to $3.4 billion. The value of imports is estimated at $2.7 billion, leaving a positive trade balance of $700 million. This is the second year in a row in which U.S. exports of farm machinery have exceeded imports. Leading export markets include Canada, Australia, Saudi Arabia, Mexico, and the European Community (EC). Canada, Japan and the EC are principal suppliers of U.S. imports. Tractors constitute the leading import and export item. Other categories include combines and other harvesting equipment, crop sprayers, and irrigation equipment.

Over the next decade, more mergers of large companies producing farm machinery are expected, according to the U.S. Industrial Outlook for 1991. In 1990, the Allis-Gleaner Company, for example, was formed to take over the Deutz-Allis portion of Klockner-Humboldt-Deutz Corporation in Germany, returning it to U.S. ownership. These tractors will once again be manufactured in the United States. Also in 1990, a merger was proposed for Ford New Holland with the Italian firm of Fiat Agri Products. This merger is presently under review by regulatory agencies. The Industrial Outlook reports an overcapacity in the farm machinery industry in Western countries at nearly double the demand. Mergers are a mechanism of adjustment to worldwide overcapacity.

Unit Sales

Four-wheel-drive tractors, as a proportion of all tractors sold, increased for the third year in a row. In 1990, four-wheel-drive tractors comprised 8 percent of all tractor sales, up

from 7 percent in 1989, 5 percent in 1988, and only 3 percent in 1987. Larger two-wheel-drive tractors have also increased as a percentage of total sales. In 1985, sales of tractors over 100 horsepower comprised 30 percent of total tractor sales, and by 1990 were 34 percent. Over the same time period the percentage of smaller tractors in the 40-to-100-horsepower range decreased from 65 to 58 percent of the total.

Sales of all farm tractors totaled 66,000 units in 1990. This compares with sales of over 100,000 units every year from 1969 to 1981, peaking in 1973 at 156,000 units. There is speculation that annual sales will again reach 100,000 units or more as farmers replace tractors that are now 10 to 20 years or older. More fundamental questions are the age of tractors on farms and when farmers replace aging units. Very little data exist to address these questions.

Despite the recent increase in tractor sales, the high sales numbers of the 1970's may not soon be repeated. One reason is the proportionate rise in sales of higher horsepower units. The 200-horsepower tractor sold today, for example, may be replacing more than one of yesterday's lower horsepower units. Farmers often find it more economical to operate one tractor with larger equipment than several tractors with smaller equipment. Another reason suggested is that farmers bought more tractors than they needed during the 1970's, not all of which will need to be replaced. Another factor is that farmers may be holding off large expenditures to limit their outstanding debt. Many are still acutely aware of friends and neighbors who overextended themselves in the 1970's, and lost farms during the lean years of the early 1980's.

Seeds

Consumption

In 1989/90, seed consumption for the eight major field crops was 6.2 million tons, a decline of 2 percent from the previous year. For the 1990/91 crop year, seed use is likely to fall 5 percent below 1989/90 use due to a decline in planted winter wheat acreage (table 42).

Consumption of planting seeds is a function of planted acreage and seeding rate per acre. Since seeding rates change slowly over time, the major factor in year-to-year changes in seed use is planted acreage. The participation rate of Government programs is often a major determinant in the level and mix of planted crop acreage.

Prices

In 1990, most field seed prices paid by farmers fell from the drought-induced levels of 1988 and 1989, as normal conditions returned and seed supplies were ample to meet demand. USDA's prices-paid index for all seeds in 1990, at

Figure 1
Seed Price Index

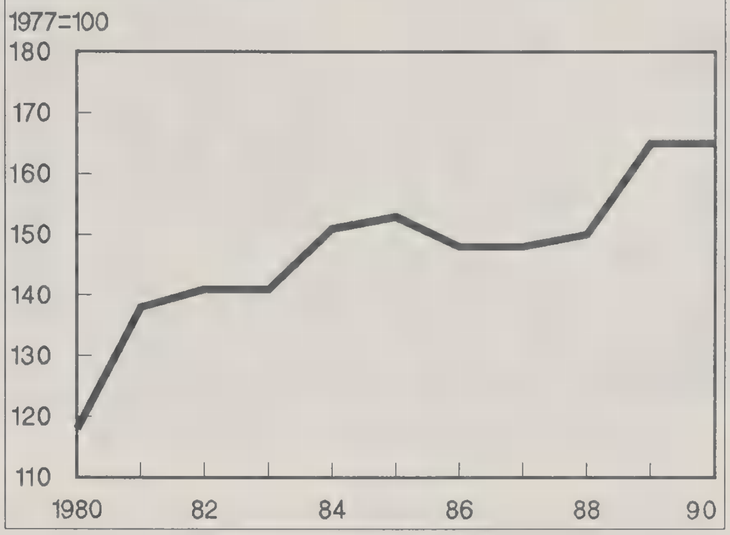


Table 42--Seed use for major U.S. field crops 1/

Crops	1987/88	1988/89	1989/90	1990/91 2/	Change 89/90-90/91
	---------	---------1,000 tons	---------	---------	Percent
Corn	482	523	532	548	3
Sorghum	36	42	30	33	[illegible]
Soybeans	1,684	1,751	1,661	1,728	4
Barley	376	360	345	349	1
Oats	505	433	371	323	-13
Wheat	2,550	3,090	3,033	2,639	-13
Rice	150	150	160	160	0
Cotton	106	89	103	120	16
Total	5,889	6,438	6,235	5,900	-5

1/ Crop marketing year. 2/ Projected based on table 1.

165, was similar to that of the previous year and is likely to remain flat in 1991 if aggregate planted acreage declines and commodity prices weaken as expected (figure 1). Seed prices for nonhybrid crops tend to track commercial crop prices.

Forage seed prices also were generally lower in 1990 due to abundant seed supplies and a decline in growth of Conservation Reserve Program (CRP) acreage. The CRP acreage grew by only 4.1 million in 1990 compared with 5.3 million in 1989, a growth decrease of 22 percent.

Farm programs will continue to influence forage seed demand over the next several years. The 1990 farm legislation (Title XIV) establishes an Agricultural Resources Conservation Program (ARC), an umbrella for the Environmental Conservation Acreage Reserve Program (ECARP), the Agricultural Water Quality Protection Program, and the Environmental Easement Program.

ECARP comprises the CRP and the Wetland Reserve Program. The acreage in ECARP, including the nearly 34 million acres currently enrolled in the CRP, cannot exceed 45 million acres. Its enrollment period, however, is extended

Table 43--Corn for grain seeding rates, plant population, and seed cost per acre, 1990 1/

States	Acres planted 2/	Rate per acre	Plant population per acre	Cost per acre
	Thousand	Kernels	Number	Dollars
IL	10,700	25,300	22,300	20.90
IN	5,600	24,800	21,900	20.40
IA	12,800	25,200	22,400	21.00
MI	2,400	24,300	20,900	20.40
MN	6,700	25,900	23,100	22.20
MO	2,100	21,900	18,000	18.90
NE	7,700	24,600	21,400	20.20
Non-irrigated	2,400	17,900	nr	15.30
Irrigated	5,300	27,500	nr	22.40
OH	3,700	26,200	22,500	22.30
SD	3,400	18,500	16,100	15.50
WI	3,700	24,700	21,800	18.50
1990 average	58,800	24,700	21,040	20.50
1989 average	57,900	24,100	20,760	20.40
1988 average	53,200	24,100	20,610	18.60

nr = None reported.
1/ States planted 79 percent of U.S. corn acres in 1990.
2/ Preliminary.

through the 1995 crop year, and additional acreage allowed to be enrolled during 1991-95 ranges between 6 and 11 million acres. Some of this acreage can be wetlands, not a demand factor for forage seed. Increase in forage seed demand due to this program will depend upon the number of CRP acres devoted to grasses. In 1991, CRP-related demand is expected to be very small and is unlikely to put upward pressure on forage seed prices.

Seeding Rates and Seed Costs Per Acre

Seeding rates and seed prices primarily determine seed cost per acre. Costs vary substantially by State and by crop. Locations where crops are generally irrigated (as in California) or where rain is normally abundant (as in the eastern Corn Belt) support heavier seeding rates, thereby raising seed costs per acre.

Corn

For the 1990 crop, the average seeding rate for the 10 leading corn producing States was 24,700 kernels per acre, 2 percent above that in 1989 as soil moisture conditions returned to normal. The average seed cost per acre was $20.50, about the same as the previous year, reflecting lower corn seed prices in 1990. The average plant population per acre for the 10 States increased 1 percent in 1990 because of favorable weather conditions (table 43).

Seeding rates (and therefore seed cost per acre) vary considerably across the Corn Belt, primarily reflecting soil productivity and moisture availability. In Nebraska, for example, the seeding rate in irrigated areas is 27,500 kernels per acre compared with 17,900 kernels in nonirrigated areas.

Ohio had the highest State seeding rate because of moisture availability, and consequently the highest seed cost per acre. South Dakota, on the other hand, typically has lower and more variable precipitation than other corn growing States, and thus has a lower seeding rate.

Soybeans

The average seeding rate for the 14 major soybean producing States was 62 pounds per acre in 1990, up 3 percent from 1989. The average seed cost per acre was $14.20, down 8 percent reflecting lower seed prices. Most of the northern soybean States, which have higher seeding rates and yields, exhibit greater seed costs per acre (table 44). Seeding rates tend to be lower in the Southern States such as Georgia, Mississippi, Tennessee, Louisiana, and Arkansas; consequently these States have lower seed costs per acre.

Farmers in the surveyed States used purchased rather than homegrown seed on 71 percent of the 1990 soybean acres. The share of 1990 acres sown with purchased seed varied widely among surveyed States, ranging from 63 percent in Tennessee to 92 percent in Louisiana. Difference in seed cost and yield often determines the choice between purchased and homegrown seed.

Spring and Durum Wheat

For the 1990 crop, the average spring wheat seeding rate was 88 pounds per acre, about the same as in 1989. The average seed cost per acre was $8.40, down 5 percent from the previous year, as average spring wheat seed prices fell 10 percent. Variation in seed prices and seeding rates resulted in per-acre costs ranging from $5.90 in Montana to $10.80 in Minnesota (table 45).

The average seed cost for Durum wheat in 1990 was $7.50 per acre, down 25 percent from 1989 reflecting lower Durum wheat seed prices in 1990. The seeding rate, however, was about the same as in 1989 (table 45).

Table 44--Soybean seeding rates, seed cost per acre, and percent seed purchased, 1990 1/

Region/State	Acres planted 2/	Rate per acre	Cost per acre 3/	Acres with purchased seed
	Thousand	Pounds	Dollars	Percent
Northern:				
IL	9,200	66	16.00	69
IN	4,300	64	14.70	75
IA	8,000	59	15.50	77
MN	4,600	65	13.10	64
MO	4,200	61	13.60	61
NE	2,400	59	14.30	76
OH	3,700	78	16.40	70
Southern:				
AR	3,100	56	11.30	68
GA	900	48	10.40	64
KY	1,250	61	12.10	68
LA	1,800	53	14.90	92
MS	2,100	53	9.90	84
NC	1,400	58	12.10	69
TN	1,300	54	10.30	63
1990 average	48,250	62	14.20	71
1989 average	51,130	60	15.50	68
1988 average	48,750	62	12.90	73

1/ States planted 84 percent of U.S. soybean acres in 1990. 2/ Preliminary. 3/ Based on data from farmers who used purchased seed.

Table 45--Spring and durum wheat seeding rates, seed cost per acre, and percent of seed purchased, 1990 1/

States	Area Planted 2/	Rate per acre	Cost per acre 3/	Acres with purchased seed
	Thousand	Pounds	Dollars	Percent
Spring:				
MN	2,800	107	10.80	56
MT	2,800	64	5.90	34
ND	8,000	88	7.80	37
SD	2,200	92	9.00	27
1990 average	15,800	88	8.40	39
1989 average	16,580	89	8.82	40
1988 average	9,780	90	8.58	46
Durum:				
ND	3,100	97	7.50	27
1990 average	3,100	97	7.50	27
1989 average	3,000	99	10.10	47
1988 average	2,500	99	8.10	47

1/ States planted 94 percent of U.S. spring wheat and 87 percent of U.S. durum wheat acres in 1990. 2/ Preliminary. 3/ Based on data from farmers who used purchased seed.

Table 46--Rice seeding rates, seed cost per acre, and percent of seed purchased, 1990 1/

States	Acres planted 2/	Rate per acre	Cost per acre 3/	Acres with purchased seed
	Thousand	Pounds	Dollars	Percent
AR	1,230	125	19.90	77
LA	570	129	22.50	99
1990 average	1,800	126	20.80	84
1989 average	2,085	134	19.87	83
1988 average	2,130	131	26.22	87

1/ States planted 63 percent of U.S. rice acres in 1990. 2/ Preliminary. 3/ Based on data from farmers who used purchased seed.

Rice

In 1990, the average seeding rate for rice was 126 pounds per acre, and the average seed cost was $20.80. Louisiana had a higher rate of 129 pounds per acre and consequently a higher cost—$22.50 per acre. Arkansas, on the other hand, had a lower rate and lower cost per acre (table 46). In 1990, farmers sowed 84 percent of the rice acreage with purchased seed. In Louisiana, nearly all of the rice acreage was planted with purchased seed.

Cotton

In 1990, the average cotton seeding rate was 17 pounds, down 5 percent from 1989. The average cost was $7.80 per acre, down 4 percent from 1989 due to the lower seeding rate (table 47).

Seeding rates and seed costs for cotton varied among surveyed States. California had the highest cost and Texas the highest rate. Although California had a lower seeding rate than Texas, its seed cost per acre was higher due to higher seed prices. The reverse occurred in Texas—a higher seeding rate but lower seed cost per acre because of lower seed

Table 47--Cotton seeding rates, seed cost per acre, and percent seed purchased, 1990 1/

States	Acres planted 2/	Rate per acre	Cost per acre 3/	Acres with purchased seed
	Thousand	Pounds	Dollars	Percent
AZ	340	16	9.30	92
AR	760	13	7.40	93
CA	1,050	16	11.20	80
LA	780	12	7.30	100
MS	1,200	12	7.60	100
TX	5,600	19	6.90	54
1990 average	9,730	17	7.80	70
1989 average	8,444	18	8.17	67
1988 average	9,700	18	8.38	86

1/ States planted 81 percent of U.S. upland cotton acres in 1990. 2/ Preliminary. 3/ Based on data from farmers who used purchased seed.

prices. In Texas the number of cottonseed varieties grown is large and competition among suppliers is intense. In California, on the other hand, the number of seed varieties available is small and the competition among suppliers is not as intense. Farmers in the surveyed States used purchased seed on 70 percent of the 1990 cotton acres.

U.S. Seed Exports and Imports

Corn Seed Exports

Compared with 1989, corn seed exports increased sharply in the first 9 months of 1990 because U.S. supplies were plentiful following favorable weather conditions, and demand abroad remained strong. The volume of U.S. field corn seed exports rose sharply to 48,415 metric tons in the first 9 months of 1990, a jump of 148 percent over the corresponding period a year earlier (table 48).

Exports to Italy, France, Spain, Canada, and Mexico—the major trading partners—were up 519, 234, 119, 151, and 14 percent, respectively, in the first 9 months of 1990 compared with the corresponding period in 1989.

Corn Seed Imports

Corn seed imports between 1987 and 1989 have accounted for a small but increasing component of U.S. consumption. Corn seed imports were 0.08 percent of use in 1987, but were 0.4 percent in 1989. The volume of corn seed imports equalled 11,354 metric tons in the first 9 months of 1990, a 40-percent decline over the same period a year earlier, as domestic seed stocks were replenished (table 49).

Canada has traditionally been the largest supplier of corn seed to the United States, while Argentina, Chile, and Hungary have exported widely varying quantities. During the first 9 months of 1990, imports from Canada rose 30 percent by volume from the corresponding period a year earlier. However, imports from Argentina, Chile, and Hungary fell 79, 36, and 76 percent during the same period as favorable

Table 48--U.S. corn seed exports by volume

Country	1987	1988	1989	January-September 1989	January-September 1990	Change 89-90
	Metric tons					Percent
Canada	2,505	2,582	1,548	1,311	3,290	151
Mexico	3,143	3,312	10,205	7,166	8,157	14
Chile	166	541	340	333	396	19
Argentina	699	808	1,215	1,196	86	-93
France	2,542	2,453	2,873	766	2,556	234
Spain	2,049	4,134	1,836	1,320	2,893	119
Italy	12,229	8,741	12,168	2,589	16,018	519
Netherlands	695	1,061	351	71	1,128	1489
Greece	1,894	2,251	1,999	1,759	1,731	-2
Turkey	2,678	1,101	245	245	59	-76
Japan	1,861	1,322	1,051	756	473	-37
Subtotal	30,461	28,306	33,831	17,512	36,787	110
Total	32,411	33,732	36,859	19,493	48,415	148

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Table 49--U.S. corn seed imports by volume

Country	1987	1988	1989	January-September 1989	January-September 1990	Change 89-90
	Metric tons					Percent
Canada	4,465	3,935	7,753	4,125	5,356	30
Argentina	0	0	2,457	2,457	511	-79
Chile	67	2,055	7,000	7,000	4,509	-36
Hungary	196	1,327	3,708	3,708	881	-76
Subtotal	4,728	7,317	20,918	17,290	11,257	-35
Total	4,754	7,909	22,672	19,021	11,354	-40

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

weather increased U.S. seed supplies. Total corn seed imports from the four countries fell 35 percent in the first 9 months of 1990 over the period a year earlier.

Soybean Seed Exports

Soybean seed exports to Italy, France, Japan, and Canada surged 183, 125, 1268, and 28 percent, respectively, in the first 9 months of 1990, as domestic soybean seed supplies increased (table 50). These increases, however, were overshadowed by a 46-percent decline in exports to Mexico. Although U.S. exports to Mexico during the first 9 months of 1990 fell sharply from the unprecedented level of 1989, they were well above the quantities typically exported to Mexico in earlier years. U.S. soybean seed exports to Mexico surged in 1989, as Mexico's domestic soybean seed supply was reduced drastically by the 1988 drought. Overall exports fell 9 percent between the corresponding periods in 1989 and 1990.

Total Exports

The value of total seed exports rose 20 percent to $419 million in the first 9 months of 1990 from the corresponding period of 1989 (table 51). This increase primarily reflects gains in corn, vegetable, and forage seed exports, which rose 147, 26, and 14 percent, respectively. These gains were partly offset by declines of 45 and 17 percent in grain sorghum and soybean seed exports.

Total Imports

As soil moisture and rainfall conditions returned to normal and domestic seed stocks were replenished, the value of total seed imports declined 20 percent to $110 million in the first 9 months of 1990 from the corresponding period of 1989. This decline largely reflects steep drops of 53 percent in corn seed imports and 22 percent in forage seed imports. The U.S. net seed trade surplus surged 46 percent to $309 million in the first 9 months of 1990 compared with the same period a year earlier (table 51).

Table 50--U.S. soybean seed exports by volume

Country	1987	1988	1989	January-September 1989	January-September 1990	Change 89-90
	Metric tons					Percent
Canada	6,087	293	390	390	499	28
Mexico	12,630	8,922	100,380	91,063	49,027	-46
France	1,404	2,187	1,698	1,196	2,689	125
Italy	44,470	27,833	20,185	14,266	40,422	183
Turkey	5,038	3,798	2,777	2,777	2,598	-6
Japan	4,151	5,277	1,608	126	1,724	1,268
Subtotal	73,780	48,310	127,038	109,818	96,959	-12
Total	75,164	53,730	128,582	110,959	100,665	-9

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Table 51--Exports and imports of U.S. seed for planting 1/

Item	1987	1988	1989	January-September 1989	January-September 1990	Change 89-90
	$ million					Percent
Exports:						
Forage	75	94	96	64	73	14
Vegetable	138	167	153	92	116	26
Flower	9	9	11	7	9	29
Corn 2/	63	67	68	36	89	147
Grain sorghum	16	29	55	40	22	-45
Soybean	36	26	54	47	39	-17
Tree/shrub	2	3	4	2	1	-50
Sugarbeet	1	2	1	1	2	100
Other	33	27	68	60	68	13
Total	373	424	510	349	419	20
Imports:						
Forage	65	52	43	36	28	-22
Vegetable	49	58	56	44	44	0
Flower	21	21	24	17	16	-6
Corn 3/	5	10	37	32	15	-53
Tree/shrub	1	2	2	1	1	0
Other	4	4	6	6	5	-17
Total	145	147	168	137	110	-20
Trade balance	228	277	342	212	309	46

1/ Totals may not add due to rounding. 2/ Not sweet, not food aid. 3/ Certified.

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Pesticide Use by Tillage System, 1988 and 1989 Corn Production

by
Len Bull

Abstract: This study examines the relationship between pesticide use and the tillage system used in production of corn in 1988 and 1989. No real difference between tillage systems was observed in the percentage of acres treated or in the number of treatments for either herbicides or insecticides. About 50 percent of the acres treated with herbicides received combination mixes as opposed to single chemicals. The exception was no-ridge till, where 60 percent were combination mixes. The 10-percent difference in mixes was made up of combinations of three or more chemicals.

Keywords: Pesticides, tillage systems, herbicide use, insecticide use, acre-treatments, pesticide use patterns

A wide variety of tillage systems has been developed and/or described over the past 40 years. Conventional tillage methods were designed to prepare a smooth residue-free seedbed, reduce weed populations, disrupt the life cycles of insect pests, and bury disease organisms. Pesticides are used to aid in this control. Conservation tillage systems, on the other hand, involve far less soil disturbance and use previous crop residues as a mulch to reduce soil erosion and conserve moisture. Labor and energy costs are usually reduced because of decreased machine operations. Herbicides, insecticides, and fungicides are used to control weeds, insects, and diseases that find a favorable habitat in this increased residue environment. While pesticides are used in conjunction with conventional tillage systems, conservation systems are often said to rely more heavily on the use of pesticides.

Current national interest is focusing on water quality and food safety, especially concerning the use of pesticides in crop production. The conservation compliance provisions of the 1985 Food Security Act (FSA) require farmers by 1995 to protect highly erodible land (HEL) through the implementation of conservation practices or they will become ineligible for farm program benefits. These concerns and provisions may force future changes toward conservation tillage systems and a change in pesticide use.

This study examines the relationship between tillage systems and the proportion of corn acreage treated with specific pesticide active ingredients for the 10 major producing States in 1988 and 1989 (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, South Dakota, and Wisconsin). Data on the quantity of pesticides applied were not available for these years. Pesticide use patterns that are identified may have implications for public policy addressing the environmental concerns of water quality and food safety.

Definitions and Methodology

Tillage systems are defined in terms of the extent of soil disturbance and the management of previous crop residues. Tillage system designations are based on the estimated residue remaining immediately after planting (1). Therefore, mechanical cultivations for after-planting weed control are not included when defining tillage systems. Residue levels are obtained by estimating the residue remaining from the previous crop and reducing this residue level by the incorporation rate of each tillage and planting implement used.

A conservation tillage system is defined as one that leaves 30 percent or more of the soil surface covered with crop residue after the planting operation. Conventional tillage methods leave less than 30 percent surface coverage and, in this study, are divided into those that use a moldboard plow and those that do not. The conservation systems include mulch tillage, no-till, and ridge tillage. For analytical purposes in this study, no-till and ridge tillage are combined into a no-ridge category.

Results

Since conservation tillage systems, particularly no-ridge till, reduce the options for mechanical weed control, increased pesticide treatments might be expected to substitute for the reduced tillage activities. Survey results, however, indicate little difference among tillage systems in the percentage of acres treated or in the number of treatments with herbicides (table A-1). While the number of treatments is nearly equal for all tillage systems, the use of combination mixes is more prevalent in no-ridge tillage systems (table A-2).

The number of mechanical weed control cultivations over 1988 and 1989 averaged about 1.3 for conventional and mulch tillage to about 1.5 for no-ridge tillage. Even though ridge till often includes after-planting cultivations to maintain the ridges as well as to control weeds, the percentage of no-ridge tillage acres that were cultivated was much less than for other tillage systems.

The average number of insecticide applications was quite similar across tillage systems. A slightly higher percentage

Table A-1--Corn acres treated with pesticide and cultivated for weed control by tillage system, 1988 and 1989

Item	Conventional				Conservation			
	With 1/		Without 1/		Mulch		No-ridge	
	1988	1989	1988	1989	1988	1989	1988	1989
Planted acres (1,000)	11,096	11,061	30,889	34,235	7,445	9,547	3,771	3,055
Percent previous crop residue:	2	2	16	16	38	38	60	64
Herbicides:								
Percent treated	93	94	98	98	95	94	99	100
Average no. of applications	1.26	1.31	1.32	1.39	1.38	1.39	1.32	1.35
Insecticides:								
Percent treated	35	34	34	29	40	40	32	40
Average no. of applications	1.01	1.01	1.03	1.03	1.05	1.02	1.12	1.03
Weed control cultivations:								
Percent cultivated	77	75	84	79	87	[illegible]	45	57
Average no. of cultivations	1.31	1.39	1.27	1.34	1.25	1.30	1.39	1.69

1/ Moldboard plow.

Table A-2--Corn herbicide acre-treatments applied as single or as combination ingredients and number of weed control cultivations by tillage system, 1988 and 1989

Item	Conventional				Conservation			
	With 1/		Without 1/		Mulch		No-ridge	
	1988	1989	1988	1989	1988	1989	1988	1989
				Percent				
Acre-treatments with: 2/								
Single ingredient:	48	50	43	51	48	53	40	39
2-way combinations:	47	44	52	44	47	42	45	43
3-way+ combinations:	4	5	4	4	3	4	14	17
Weed control cultivations:								
0 cultivations	23	25	16	21	13	17	55	43
1 cultivation	55	50	63	56	66	60	26	21
2 cultivations	21	20	19	20	21	22	18	32
3+ cultivations	1	4	2	3	1	1	1	4

1/ Moldboard plow. 2/ Acre treatments = treated acres times average applications.

of acres treated was reported for mulch and no-ridge tillage systems than for conventional systems. This could be due in part to a higher proportion of conservation tillage rotations containing corn following corn, which allows a buildup of corn rootworm.

About 50 percent of the acreage treated with herbicides received combination mixes as opposed to single active ingredients (table A-2). This held true for all except no-ridge till, where 60 percent was treated with combination mixes, the 10-percent difference made up of the three or more combinations. The use of more combinations of herbicides in no-ridge till could be due to broader spectrum weed problems resulting from herbicide non-incorporation and/or decreased tillage operations. Other factors may be an attempt to minimize trips over the field and the possibility that no-ridge-till operators are better managers who mix chemicals to target their weed control efforts more effectively.

Active Ingredients

Herbicides

Herbicide products can be applied as single active ingredients or as combination mixes where two or more active ingredients are combined and applied together in one trip over the field. Because a single herbicide does not effectively control all weed species, herbicide combinations broaden the spectrum of weed control. Combination mixes can be either formulated premix products, or tank mixes of two or more individual products. In formulated premix products, the manufacturer mixes the active ingredients before packaging and sale to the farmer. With tank mixes, the farmer purchases the active ingredients separately and mixes them in a spray tank before field application.

Atrazine and alachlor, applied either as single materials or in combination mixes, were the two most commonly used herbi-

Table A-3--Herbicide acre-treatments by active ingredient and tillage system

Item	Conventional				Conservation			
	With 1/		Without 1/		Mulch		No-ridge	
	1988	1989	1988	1989	1988	1989	1988	1989
Acre-treatments by active ingredient: 2/								
	Percent							
Single materials--								
Alachlor	9	8	7	8	7	12	7	7
Atrazine	12	11	9	5	8	6	9	5
Bromoxynil	3	1	2	2	3	2	1	3
Butylate	nr	*	1	1	nr	3	nr	nr
Cyanazine	3	2	2	3	3	1	4	4
Dicamba	5	6	5	7	5	5	6	6
EPTC	5	7	4	6	6	5	1	nr
Glyphosate	*	2	*	*	1	*	3	1
Metolachlor	3	6	5	8	8	10	3	6
Paraquat	nr	nr	nr	*	nr	*	1	2
Propachlor	1	*	1	1	1	2	2	nr
2,4-D	5	5	5	7	7	4	2	5
Other	1	2	1	3	nr	2	1	1
Combinations--								
Atrazine + alachlor	19	11	15	11	12	9	6	14
Atrazine + bromoxynil	1	1	2	2	3	4	1	2
Atrazine + butylate	1	4	5	3	2	1	1	nr
Atrazine + cyanazine	3	3	6	5	11	7	19	10
Atrazine + dicamba	1	4	2	4	3	4	2	2
Atrazine + EPTC	2	2	1	1	2	nr	nr	1
Atrazine + metolachlor	9	8	12	8	9	6	7	11
Atrazine + pendimethalin	nr	1	*	1	1	1	nr	nr
Atrazine + 2,4-D	*	*	*	*	*	1	1	nr
Cyanazine + alachlor	3	3	1	2	1	1	2	1
Cyanazine + metolachlor	1	2	1	1	*	1	nr	nr
Dicamba + 2,4-D	3	2	3	3	2	4	4	1
Other 2-way	4	4	5	4	2	4	3	2
3-way	4	5	4	4	3	4	14	17
Total	100	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent.

1/ Moldboard plow. 2/ Acre-treatments = treated acres times average applications.

cides across all tillage systems (table A-3). Atrazine is very effective in controlling annual broadleaf weeds and can be applied preplant, preemergence, or postemergence. Alachlor controls annual grasses and can be applied preplant or preemergence. It also helps control yellow nutsedge. A mix of atrazine + metolachlor was also used across all tillage systems. Metolachlor is from the same chemical family as alachlor and thus is often used as a substitute. Dicamba, 2,4-D, and metolachlor are other single materials that were used across all tillage systems. Dicamba and 2,4-D are effective in controlling actively growing broadleaf weeds with little or no effect on grasses.

A mix of atrazine + cyanazine was used more extensively in no-ridge tillage systems. Cyanazine has a shorter soil persistence and controls most annual grasses better than atrazine. The combination provides a broader spectrum weed control and requires less atrazine than would an atrazine application alone. This would be of particular importance in a corn-soybean rotation where atrazine carryover may be a concern. It would also be useful if a farmer wished to make a preplant application and maintain the option of planting either corn or soybeans. During a wet spring, for example, this option would be desirable.

Combinations of three or more active ingredients in a single application were more common in the no-ridge tillage system. All combinations included atrazine plus cyanazine, alachlor, and/or metolachlor. In addition, either dicamba, 2,4-D, glyphosate, or paraquat were frequently included.

The inclusion of dicamba and 2,4-D in these combination mixes provides effective low-cost control of emerged broadleaf weeds. Glyphosate and paraquat are nonselective herbicides used to control existing vegetation before the crop emerges and are fairly expensive. Glyphosate translocates to the roots, giving excellent control of annual weeds and good control of perennial weeds. Paraquat kills annual weeds but only knocks down the foliage of perennial weeds and, since it is not translocated to the roots, regrowth of perennials can occur.

"Conventional wisdom" sometimes assumes that a no-ridge tillage system needs a nonselective herbicide (paraquat or glyphosate) to kill existing vegetation before planting. However, survey results do not indicate this type of use. This is largely explained by the fact that in the 10 surveyed States, only a small proportion of the corn acreage is planted into the type of residue (alfalfa, grass, or a cover crop) (2) where such an herbicide is needed.

Table A-4--Insecticide acre-treatments by active ingredient and tillage system

Item	Conventional				Conservation			
	With 1/		Without 1/		Mulch		No-ridge	
	1988	1989	1988	1989	1988	1989	1988	1989
	Percent							
Acre-treatments by active ingredient: 2/								
Carbofuran	10	7	6	6	7	[illegible]	16	10
Chlorpyrifos	25	31	31	29	35	18	23	20
Fonofos	14	8	11	12	14	20	14	10
Permethrin	2	1	6	4	3	2	nr	4
Phorate	12	10	7	6	4	6	7	5
Terbufos	32	34	32	33	28	37	31	37
Other	5	10	6	10	8	8	9	15
Total	100	100	100	100	100	100	100	100

1/ Moldboard plow. 2/ Acre-treatments = treated acres times average applications.

Insecticides

Terbufos and chlorpyrifos were the two most widely used insecticides across all tillage systems (table A-4). Both materials are used to control corn rootworm larvae, which can be a problem in cropping patterns of corn following corn. In addition, chlorpyrifos can be used to control cutworms, which may be more of a problem in conservation tillage systems.

Summary and Conclusions

The percentage of acres treated and the number of pesticide applications did not indicate significant differences between tillage systems in 1988 and 1989 corn production. The no-till and ridge-till systems employed greater use of combination mixes than other tillage systems. Other pest management practices, the crop rotation, yearly moisture and its timing, and other factors influencing pest populations would appear to have a greater impact upon the extent of pesticide use than the type of tillage system.

Half of the herbicide applications were applied as combinations of two or more active ingredients. Herbicides used in no-ridge tillage contained more combinations of three or more active ingredients. The weed problem in no-ridge tillage may be of a broader nature since preplant incorporation of herbicides is not possible in these tillage systems.

References

1. Bull, Len. "Residue and Tillage Systems in 1987 Corn Production," *Agricultural Resources: Inputs Situation and Outlook*, AR-13, ERS, USDA, February 1989.

2. Daberkow, Stan, and Mohinder Gill. "Common Crop Rotations Among Major Field Crops," *Agricultural Resources: Inputs Situation and Outlook*, AR-15, ERS, USDA, August 1989.

A Statistical Analysis of Fertilizer Application Rate Differences Between 1989 and 1990

by
Harold H. Taylor

Abstract: Differences between 1989 and 1990 mean application rates of nitrogen, phosphate, and potash on corn, cotton, soybeans, rice, and wheat were evaluated to determine if any of these variations were statistically different from zero at the 1-, 5-, or 10-percent level of confidence. Differences in nitrogen application rates on soybeans, rice, and winter wheat; phosphate on winter wheat; and potash on cotton and soybeans were significant at the 1-percent level. Potash used on rice was significant at the 10-percent level. More differences were found to be significant for each crop by State since State-level analysis was done from smaller sample sizes and with more variability than for area data.

Keywords: Nitrogen, phosphate, potash, mean differences, statistical analysis

Yearly variation in fertilizer application rates derived from a probability-based survey can be explained by a variety of factors. Sample size, design, and data estimates, as well as interviewer error are contributing factors. In addition, farmers may adjust the amount per application and the number of applications per crop year. Farmers make modifications when future market conditions are expected to change, when Government programs or program participation levels change, when excessive wet or dry weather conditions exist, when purchase costs of fertilizer change, or when nutrient carryover in the soil from the previous year varies significantly from expectations. The goal of this report is to analyze the difference in mean application rates in 1989 and 1990, if any, under the assumption of no statistical difference.

Statistical Procedure

Fertilizer application rates for corn, cotton, soybeans, rice, and wheat were estimated from a survey of fields in the major producing States for 1989 and 1990. The quantity of nitrogen, phosphate, and potash per fertilizer application for each selected field, and the number of applications per field were used to estimate per-acre application rates of nitrogen, phosphate, and potash. The survey design determined how field- level data (average application rates for each field in the survey) would be weighted to derive per-acre average application rates representative of each State and for the total sample area.

A General Linear Model was used to evaluate State and area differences in nitrogen, phosphate, and potash application rates between 1989 and 1990 for corn, cotton, soybeans, rice, and wheat, and to determine whether these differences were statistically different from zero at a specified level of significance. The analysis used weighted least squares regression procedures and dummy variables in model formulations (1,2,3,4,5). For each observation sampled, the computed application rate became the dependent variable with year (a set of dummy variables) as the independent variable. When the regression equation was solved, the constant term contained the mean value for 1990, and the value for the dummy variable (year) contained the difference between the means of the two years. The F statistic was then used to test the null hypothesis of no difference in average application rates between 1989 and 1990 at the 10-, 5-, and 1-percent levels of confidence.

The level of confidence is a measurement that indicates the degree of reliability placed on the hypothesis of no difference between means. For example, at the 10-percent level of confidence there is a chance that in 10 out of 100 times a wrong conclusion can be made (i.e., differences in means are significantly different from zero but we conclude that there is no difference). At the 1-percent level of confidence there is a chance that in 1 out of 100 times a wrong conclusion can be made.

Table B-1 contains the average application rates for 1989 and 1990 and their differences by crop, while tables B-2 to B-6 contain the same information by crop and State. Differences in average application rates that were found to be statistically different from zero at a specified level of significance are indicated.

Results of the Analysis

Differences in the average nitrogen application rates on soybeans, rice, and winter wheat were statistically different from zero at the 1-percent level of confidence (table B-1). Differences in mean nitrogen application rates for the other crops were not found to be significant. Winter wheat was the only crop which had a statistical difference in the mean phosphate application rate. This difference was significant at the 1-percent level. Only cotton, soybeans, and rice showed statistical differences in the mean potash application rates. Differences for cotton and soybeans were significant at the 1- percent level, and for rice at the 10-percent level.

Table B-1--Comparision between mean application rates (1989 and 1990)

Crop	Nitrogen 1990	Nitrogen 1989	Nitrogen Difference	Phosphate 1990	Phosphate 1989	Phosphate Difference	Potash 1990	Potash 1989	Potash Difference
Corn	132.08	131.22	-0.86	60.39	59.22	-1.17	83.77	80.95	-2.83
Cotton	85.76	83.58	-2.18	44.29	42.62	-1.67	47.31	39.99	-7.33 *
Soybeans	24.16	17.84	-6.32 *	47.24	45.75	-1.49	81.02	73.72	-7.31 *
Rice	114.43	124.86	10.42 *	45.20	44.72	-0.47	48.95	44.74	-4.21 ***
Wheat:									
Durum	35.31	33.04	-2.27	25.28	26.30	1.02	7.55	4.86	-2.69
Spring	52.74	51.86	-0.87	33.49	30.38	-3.11	22.98	24.01	1.03
Winter	62.41	68.63	6.22 *	38.33	41.87	3.54 *	56.86	56.00	-0.86

* = Difference in means is significantly different from zero at the 1-percent level of confidence.
*** = Difference in means is significantly different from zero at the 10-percent level of confidence.

Table B-2--Comparision between mean application rates for corn by State (1989 and 1990)

Crop	Nitrogen 1990	Nitrogen 1989	Nitrogen Difference	Phosphate 1990	Phosphate 1989	Phosphate Difference	Potash 1990	Potash 1989	Potash Difference
Corn:									
Illinois	163.75	160.38	-3.37	81.47	74.34	-7.13 **	107.38	101.47	-5.91
Indiana	139.22	133.08	-6.14	74.75	78.33	3.58	111.13	109.63	-1.50
Iowa	127.35	128.04	0.69	58.17	57.38	-0.79	74.49	69.27	-5.22 ***
Michigan	122.75	111.06	-11.69	52.12	52.19	0.07	95.42	104.99	9.57
Minnesota	113.48	114.78	1.30	51.00	49.27	-1.73	69.14	63.41	-5.73
Missouri	133.25	139.99	6.74	57.94	58.07	0.13	79.76	72.29	-7.47
Nebraska	143.53	145.32	1.79	31.46	36.11	4.65 **	22.20	23.34	1.14
Ohio	151.28	143.06	-8.22	71.68	71.67	-0.01	101.38	101.26	-0.12
South Dakota	79.72	69.18	-10.54 ***	41.80	33.19	-8.61 ***	23.56	22.97	-0.59
Wisconsin	78.70	87.71	9.01	51.51	54.89	3.37	74.19	72.81	-1.39
Area	132.08	131.22	-0.86	60.39	59.22	-1.17	83.77	80.95	-2.83

** = Difference in means is significantly different from zero at the 5-percent level of confidence.
*** = Difference in means is significantly different from zero at the 10-percent level of confidence.

Table B-3--Comparision between mean application rates for cotton by State (1989 and 1990)

Crop	Nitrogen 1990	Nitrogen 1989	Nitrogen Difference	Phosphate 1990	Phosphate 1989	Phosphate Difference	Potash 1990	Potash 1989	Potash Difference
Cotton:									
Arizona	155.37	178.33	22.96 ***	67.68	64.07	-3.61	20.72	2.30	-18.42
Arkansas	85.27	79.73	-5.54	35.84	35.28	-0.56	56.86	61.60	4.74
California	139.83	123.03	-16.81 **	68.03	55.61	-12.42 ***	39.97	14.17	-25.80 *
Louisiana	77.22	86.19	8.97	48.49	44.76	-3.73	62.22	55.01	-7.22
Mississippi	109.34	103.11	-6.23	50.31	49.27	-1.04	78.08	65.31	-12.77 **
Texas	59.49	47.91	-11.58 *	40.12	37.40	-2.72	17.08	11.77	-5.31 **
Area	85.76	83.58	-2.18	44.29	42.62	-1.67	47.31	39.99	-7.33 *

* = Difference in means is significantly different from zero at the 1-percent level of confidence.
** = Difference in means is significantly different from zero at the 5-percent level of confidence.
*** = Difference in means is significantly different from zero at the 10-percent level of confidence.

Table B-4--Comparision between mean application rates for soybeans by State (1989 and 1990)

Crop	Nitrogen 1990	Nitrogen 1989	Nitrogen Difference	Phosphate 1990	Phosphate 1989	Phosphate Difference	Potash 1990	Potash 1989	Potash Difference
Soybeans:									
Arkansas	38.42	15.72	-22.70 **	53.05	36.60	-16.45 *	66.77	56.67	-10.11 **
Georgia	18.69	19.54	0.85	40.43	40.47	0.04	68.67	76.10	7.43
Illinois	25.25	17.29	-7.96	58.23	54.12	-4.11	95.62	85.09	-10.53
Indiana	15.82	12.23	-3.59	41.08	47.51	6.43	90.32	81.39	-8.93
Iowa	33.71	15.90	-17.81 ***	40.16	50.43	10.27 **	56.07	68.19	12.12
Kentucky	39.58	24.25	-15.33 **	71.51	62.79	-8.72	84.07	75.51	-8.56
Louisiana	22.99	23.64	0.65	44.88	40.84	-4.04	54.71	60.06	5.35
Minnesota	15.91	15.61	-0.30	33.54	33.54	0.01	62.27	51.03	-11.24
Mississippi	43.29	15.54	-27.74	38.73	41.66	2.92	67.27	62.83	-4.44
MIssouri	20.73	24.90	0.76	41.33	40.78	-0.55	62.69	68.87	6.18
Nebraska	32.02	15.54	-16.47	40.39	35.54	-4.85	32.00	22.57	-9.43
North Carolina	15.93	24.47	8.54	40.42	39.82	-0.60	84.54	79.80	-4.75
Ohio	11.10	13.97	2.87	47.94	54.71	6.77	105.42	92.89	-12.52
Tennessee	30.03	20.90	-9.13	41.56	42.61	1.04	55.97	60.92	4.96
Area	24.16	17.84	-6.32 *	47.24	45.75	-1.49	81.02	73.72	-7.31 *

* = Difference in means is significantly different from zero at the 1-percent level of confidence.
** = Difference in means is significantly different from zero at the 5-percent level of confidence.
*** = Difference in means is significantly different from zero at the 10-percent level of confidence.

Table B-5--Comparision between mean application rates for rice by State (1989 and 1990)

Crop	Nitrogen			Phosphate			Potash		
	1990	1989	Difference	1990	1989	Difference	1990	1989	Difference
Rice:									
Arkansas	114.10	125.14	11.04 **	46.72	32.28	-14.45 *	56.50	44.89	-11.61 **
California	nr	144.35	nr	nr	50.73	nr	nr	44.40	nr
Louisiana	115.13	108.68	-6.45	44.58	46.93	2.34	45.34	44.68	-0.66
Area	114.43	124.86	10.42 *	45.20	44.72	-0.47	48.95	44.74	-4.21 ***

* = Difference in means is significantly different from zero at the 1-percent level of confidence.
** = Difference in means is significantly different from zero at the 5-percent level of confidence.
*** = Difference in means is significantly different from zero at the 10-percent level of confidence.

For all other crops and nutrients, the mean application rates were not statistically different between 1989 and 1990.

A greater variation in mean application rates for nitrogen, phosphate, and potash existed at the State level for each crop. For example, mean differences in application rates on the U.S. corn crop for each nutrient were not significant; however, some State-level comparisons of differences for corn were significant (table B-2). Significant mean differences at the 10-percent level for nitrogen and phosphate application rates on corn existed for South Dakota, and potash application rates for Iowa. Phosphate application rates on corn were statistically different from zero at the 5-percent level in Illinois and Nebraska.

Mean differences in application rates on the U.S. cotton crop were not found to be statistically different from zero for nitrogen and phosphate, but the potash application rate difference was significant at the 1-percent level (table B-3). However, at the State level, significant differences in application rates for each of the nutrients were detected. Significant differences were obtained for mean nitrogen application rates for Arizona, California, and Texas at the 10-, 5-, and 1-percent levels. The difference in the mean phosphate application rate for California cotton was significant at the 10-percent level, while potash differences were significant for California, Mississippi, and Texas cotton at the 1-, 5-, and 5-percent levels.

State-level differences in soybean application rates for nitrogen, phosphate, and potash were also significant among some States (table B-4). Differences in nitrogen application rates were significantly different from zero for Arkansas soybeans at the 5-percent level, Iowa soybeans at the 10-percent level, and Kentucky soybeans at the 5-percent level. Differences in phosphate application rates for Arkansas and Iowa soybeans were significant at the 1- and 5-percent levels. The difference in the mean potash application rate for Arkansas soybeans was significant at the 5-percent level. No other States had a significant difference in soybean potash application rates, indicating that potash application rates likely were unchanged between 1989 and 1990.

The State of Arkansas had statistically significant differences in mean application rates for rice for all three nutrients (table B-5). Differences in nitrogen and potash application rates were significant at the 5-percent level, and phosphate at the 1-percent level. No other rice States had statistically significant differences in average application rates.

State-level spring wheat showed statistical differences in mean application rates for nitrogen and potash at the 10-percent level (table B-6). Minnesota and South Dakota showed differences for nitrogen, while differences were found in North and South Dakota for potash. No other spring wheat States had significant differences in average application rates.

Winter wheat State-level data showed significant differences for some States and nutrients (table B-6). Differences in mean nitrogen application rates for Kansas were significant at the 10-percent level, while for Montana, Nebraska, and Oklahoma, differences were significant at the 5-percent level. Kansas and Washington were the only winter wheat States that showed a significant difference in phosphate application rates. Differences in phosphate application rates in Kansas were significant at the 10-percent level, while in Washington differences were significant at the 5-percent level. The States of Illinois and Texas had significant differences in potash application rates at the 10- and 5-percent levels.

Generalization

At the aggregate area level of analysis, differences in mean application rates for a specified level of significance are less than at the State level since State-level data are obtained from a smaller sample size and have greater variation than the area-level data. For example, 1989-90 area-level differences in nitrogen application rates for soybeans and winter wheat of over 6 pounds per acre are needed to be considered significantly different from zero at the 1-percent level of confidence.

No significant differences in nitrogen application rates at the 1-percent level of confidence were detected for any State-level data. However, nitrogen differences of 15.3 and 22.7 pounds per acre for Kentucky and Arkansas soybeans are necessary for significance at the 5-percent level of confidence, while winter wheat States of Montana, Nebraska, and

Table B-6--Comparision between mean application rates for wheat by State (1989 and 1990)

Crop	Nitrogen			Phosphate			Potash		
	1990	1989	Difference	1990	1989	Difference	1990	1989	Difference
Durum wheat:									
North Dakota	35.31	33.04	-2.27	25.28	26.30	1.02	7.55	4.86	-2.69
Spring wheat:									
Idaho	nr	99.40	nr	nr	47.62	nr	nr	30.50	nr
Minnesota	82.70	71.76	-10.94 ***	42.38	37.32	-5.07	34.47	27.82	-6.65
Montana	39.33	33.32	-6.00	29.68	24.02	-5.66	6.86	15.19	8.33
North Dakota	44.32	44.17	-0.15	31.11	28.54	-2.58	12.47	19.95	7.49 ***
South Dakota	40.45	53.77	13.31 ***	28.83	27.86	-0.97	7.80	21.67	13.87 ***
Area	52.74	51.86	-0.87	33.49	30.38	-3.11	22.98	24.01	1.03
Winter wheat:									
Arkansas	99.95	99.13	-0.82	41.12	44.98	3.86	55.33	53.66	-1.67
California	nr	104.88	nr	nr	42.58	nr	nr	22.09	nr
Colorado	40.66	45.22	4.56	22.47	32.19	9.72	nr	nr	nr
Idaho	nr	92.37	nr	nr	35.67	nr	nr	32.80	nr
Illinois	85.30	90.14	4.84	73.80	72.24	-1.56	91.34	79.29	-12.05 ***
Indiana	nr	76.36	nr	nr	62.75	nr	nr	65.31	nr
Kansas	49.14	53.44	4.30 ***	29.12	32.01	2.89 ***	20.84	28.55	7.70
Missouri	84.19	86.24	2.05	51.40	54.23	2.82	70.70	66.64	-4.06
Montana	47.04	34.39	-12.65 **	27.75	27.94	0.19	17.37	7.59	-9.78
Nebraska	50.48	40.92	-9.55 **	27.39	30.41	3.02	5.75	nr	nr
Ohio	75.24	78.72	3.48	65.66	60.20	-5.45	70.31	66.84	-3.47
Oklahoma	65.22	75.01	9.79 **	33.86	36.40	2.54	25.22	22.03	-3.18
Oregon	nr	75.20	nr	nr	43.79	nr	nr	37.93	nr
South Dakota	35.43	nr	nr	24.23	nr	nr	4.74	nr	nr
Texas	88.01	88.56	0.54	36.53	40.72	4.19	10.06	25.91	15.85 **
Washington	64.84	65.99	1.15	19.37	29.70	10.33 **	2.00	11.28	9.28
Area	62.41	68.63	6.22 *	38.33	41.87	3.54 *	56.86	56.00	-0.86

* = Difference in means is significantly different from zero at the 1-percent level of confidence.
** = Difference in means is significantly different from zero at the 5-percent level of confidence.
*** = Difference in means is significantly different from zero at the 10-percemt level of confidence.

Oklahoma require nitrogen differences of 12.7, 9.6, and 9.8 pounds per acre. Kansas requires a difference of 4.3 pounds for significance at the 10-percent level.

Similar comparisons could be made for the other crops and States. What is clear is that sampling variation must be considered before concluding that fertilizer application rates have increased or decreased from one year to the next.

References

1. Freund, Rudolf J., and Ramon C. Littell. *SAS for Linear Models*. Raleigh, North Carolina: SAS Institute Inc., 1981.
2. Hallberg, M. C. *Statistical Analysis of Single Equation Stochastic Models Using the Digital Computer*. The Penn sylvania State University, A.E. and R.S. 78, February 1969.
3. Ferber, Robert, and P. J. Verdoorn. *Research Methods in Economics and Business*. New York: Macmillan, 1962, pp. 369-380.
4. Johnston, J. *Econometric Methods*. New York: McGraw-Hill, 1972, pp. 176-186.
5. Cleary, James P., and Hans Levenbach. *The Professional Forecaster*. Belmont, California: Wadsworth, Inc., 1986, pp. 156-166.

Cropping Pattern Comparisons Between 1989 and 1988

by

Mohinder Gill and Stan Daberkow

Abstract: Based on survey data for 1988 and 1989, crop patterns were compared for the major field crops. The analysis indicates that while overall cropping patterns remained stable between the two years, individual States exhibited some changes. The 1989 data indicate that for most areas of the United States, wide use of crop rotation continues. However, for certain crops and States, continuous cropping is still practiced because of economic and agroclimatic factors.

Keywords: Cropping pattern, crop rotations, production, diversity

Crop rotation continues to be emphasized as a production practice to reduce chemical use in agriculture, control soil erosion, improve soil productivity, assist in risk management, and possibly contribute to profitability (1,4). For example, 1987 continuous corn land in the 10 largest corn producing States received over 10 more pounds of nitrogen per acre than did noncontinuous corn (5). In addition, about 75 percent of the continuous corn acres were treated with insecticides, compared with less than 30 percent of the noncontinuous corn acres. Field trials on corn rootworm have shown that the life cycle of the pest is interrupted, and less insecticide required, when corn is preceded by another crop (3). The "rotation effect," which is the effect on yield as farmers move away from monoculture cropping, has been shown by most research to be positive (4). Numerous research, education, and extension activities are underway to explore the potential of adopting crop rotation in all regions of the United States.

The recently passed 1990 farm bill includes several programs aimed at either removing barriers or providing financial incentives to adopt crop rotation. Specific provisions encouraging rotation include the new crop base flexibility regulations, the Agricultural Water Quality Incentive Program, the Integrated Farm Management Option, and increased authorizations for research on sustainable agriculture and integrated management systems.

This article uses survey data for major field crops grown in 1988 and 1989 and examines the share of acreage on which various three-year cropping patterns were practiced. Survey data for the major field crops produced during 1989 indicate that for most areas of the United States, farmers are already extensively utilizing crop rotations. While individual States vary their cropping patterns from year to year, comparisons between 1988 and 1989 crop production patterns indicate little overall change. For certain crops and States, continuous cropping is still widely practiced. Farmers in these areas of the country will likely examine and take advantage of the various crop rotation incentives provided by the 1990 farm bill.

Corn

In 1989, in the 10 major corn producing States, the two most common cropping sequences on land producing corn were continuous corn production and corn-soybean-corn rotations (table C-1)—similar to the 1988 cropping pattern. These two sequences were used on nearly 61 percent of the 1989 acreage and 65 percent of 1988 acreage. Continuous corn was most common in Nebraska—60 percent in 1989 and 62 percent in 1988. The share of the irrigated areas of the State which followed this pattern was 79 percent in both years. Fixed investment in irrigation capital and heavy participation in the commodity programs have likely contributed to a lack of crop diversity.

While overall cropping patterns remained stable between 1988 and 1989, several States exhibited some diversity. Continuous corn production acreage in Illinois, Indiana, Minnesota, and Missouri fell 7, 5, 6, and 8 percentage points between 1988 and 1989. Soybean-corn-corn acreage, on the other hand, increased 3, 5, 4, and 7 percentage points. A significant change also occurred in Missouri where the share of corn-soybean-corn rotation acreage fell 15 percentage points and soybean-soybean-corn acreage increased 6 percentage points between 1988 and 1989. Both economic and environmental concerns may have contributed to these shifting land use patterns.

Winter Wheat

In the United States much of the winter wheat is grown on the moisture-deficient areas of the Great Plains. Therefore, one of the most common rotations was the moisture-conserving wheat-fallow-wheat pattern. In 1989, 26 percent of the winter wheat acreage followed this rotation (table C-2). The States which dominantly exhibited this pattern included: Colorado (72 percent), Oregon (65 percent), Washington (57 percent), Montana (53 percent), Nebraska (52 percent), Kansas (31 percent), and Idaho (21 percent). This land use was similar to the use of winter wheat acreage in 1988. Only the ranking of States was somewhat altered between the two years.

Table C-1--Cropping patterns used on land producing corn, 1989

Previous crop 1988	1987	IL	IN	IA	MI	MN	MO	Nebraska State	Nebraska Dry	Nebraska Irr.	OH	SD	WI	Area	1988 Area
		Million acres planted													
		10.90	5.5	12.7	2.3	6.2	2.4	7.5	2.3	4.6	3.4	3.4	3.6	57.9	53.2
		Percent													
Corn	Corn	15	15	19	33	13	10	60	17	79	16	9	36	23	26
Corn	Soybean	8	16	8	3	7	14	4	8	2	7	1	2	7	5
Corn	Alfalfa	1	nr	1	4	5	nr	1	3	nr	1	1	16	2	3
Corn	Other	2	2	3	13	3	3	3	2	4	3	5	9	4	3
Wheat	Corn	nr	3	*	3	nr	6	nr	nr	1	3	6	1	2	1
Wheat	Other	4	2	nr	5	*	10	3	5	1	7	9	1	4	3
Fallow 1/	Other	2	3	1	7	4	4	5	9	3	6	9	1	4	2/
Soybean	Corn	58	44	56	8	40	22	17	46	3	30	21	3	38	38
Soybean	Soybean	3	6	4	6	5	18	1	1	nr	15	3	1	5	4
Soybean	Other	3	4	1	5	4	8	nr	nr	nr	5	8	2	4	3
Alfalfa	Alfalfa	*	*	1	4	3	nr	nr	nr	nr	3	2	16	2	4
Alfalfa	Other	1	nr	2	nr	*	2	nr	nr	nr	1	nr	2	1	1
Oats	Corn	nr	nr	1	nr	2	nr	nr	nr	nr	nr	12	2	1	1
Oats	Other	nr	nr	1	nr	*	nr	*	2	nr	nr	2	nr	1	1
Sub-total		97	97	99	92	89	95	94	95	93	97	88	92	98	94
Other	Other	3	3	1	8	11	5	6	5	7	3	12	8	2	6
	Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100

nr = None reported. * = less than 1 percent.

1/ Fallow includes land idle under farm commodity program provisions. 2/ Included in other.

Table C-2--Cropping patterns used on land producing winter wheat, 1988/89

Previous crop 1988	1987	AR	CA	CO	ID	IL	IN	KS	MO	MT	NE	OH	OK	OR	TX	WA	Area	1988 Area
		Million acres harvested																
		1.35	0.57	2.10	0.81	1.80	0.88	9.60	1.85	1.70	2.05	1.20	5.70	0.80	3.00	1.30	34.71	32.83
		Percent																
Corn	Soybean	nr	nr	nr	nr	7	7	*	7	nr	nr	nr	nr	nr	nr	nr	1	1
Corn	Other	nr	5	nr	1	10	11	1	7	nr	nr	5	6	nr	4	nr	3	2
Wheat	Wheat	3	5	1	7	nr	nr	23	nr	nr	5	2	78	3	30	2	23	20
Wheat	Other	3	9	3	13	8	12	12	16	3	7	14	5	1	20	2	9	8
Soybean	Wheat	1	nr	nr	nr	3	4	*	7	nr	nr	5	nr	nr	2	nr	1	1
Soybean	Soybean	45	nr	nr	nr	18	4	3	15	nr	nr	12	nr	nr	nr	nr	5	3
Soybean	Corn	nr	nr	nr	nr	38	38	nr	19	nr	nr	40	nr	nr	nr	nr	5	5
Soybean	Other	24	nr	nr	nr	6	4	3	13	nr	nr	1	nr	nr	nr	nr	3	3
Fallow 1/	Wheat	nr	9	72	21	nr	nr	31	nr	53	52	2	5	65	12	57	26	32
Fallow	Barley	nr	nr	nr	3	nr	nr	*	nr	23	1	nr	nr	1	nr	17	2	3
Fallow	Sorghum	nr	nr	nr	nr	nr	nr	11	nr	nr	7	nr	1	nr	10	nr	6	7
Fallow	Other	11	8	22	18	nr	18	7	4	5	19	10	1	12	8	6	9	6
Cotton	Cotton	3	16	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	2	nr	*	2/
Cotton	Other	1	13	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	*	*
Sub-total		91	65	98	63	90	98	91	88	94	91	90	96	82	98	84	93	91
Other	Other	9	35	2	37	10	2	9	12	6	9	10	4	18	2	16	7	9
	Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent.

1/ Fallow includes land idled under farm commodity program provisions. 2/ Included in other.

Table C-3--Cropping patterns used on land producing spring and durum wheat, 1989

Previous crop		Spring wheat							Durum wheat	
1988	1987	ID	MN	MT	ND	SD	Area	1988 Area	ND	1988 Area
		Million acres planted								
		0.58	2.60	3.50	7.70	2.20	16.58	9.78	3.00	2.5
		Percent								
Soybean	Corn	nr	11	nr	1	4	3	2	nr	nr
Soybean	Wheat	nr	16	nr	4	8	6	6	nr	1
Soybean	Other	nr	5	nr	4	6	3	3	1	nr
Fallow 1/	Wheat	[illegible]	4	62	17	14	24	27	37	39
Fallow	Barley	nr	nr	16	5	nr	6	[illegible]	6	18
Fallow	Other	nr	nr	3	10	6	7	14	12	20
Potatoes	Wheat	12	1	nr	1	nr	1	1	nr	nr
Potatoes	Other	12	1	nr	nr	nr	1	2	nr	1
Sugarbeet	Wheat	4	nr	nr	2	nr	1	3	nr	1
Sugarbeet	Other	10	4	nr	1	nr	1	2/	nr	2/
Corn	Other	nr	11	nr	3	16	5	4	nr	1
Wheat	Wheat	8	13	2	11	12	10	2/	5	2/
Wheat	Fallow	2	4	5	12	4	8	2/	22	2/
Wheat	Other	14	12	2	9	6	7	13	2	15
Barley	Other	10	7	3	3	10	5	2/	7	2/
Sub-total		80	89	93	83	86	88	83	92	96
Other	Other	20	11	7	17	14	12	17	8	4
	Total	100	100	100	100	100	100	100	100	100

nr = None reported.

1/ Fallow includes land idled under farm commodity program provision.
2/ Included in other.

Continuous wheat production was the second most popular cropping pattern. In parts of Texas, Kansas, and Oklahoma, enough moisture is available to permit continuous wheat production. While the overall cropping pattern remained relatively stable between 1988 and 1989, the individual States reflected some changes from 1988. Continuous wheat acreage was up by 8 and 6 percentage points in Oklahoma and Kansas, falling 10 percentage points in Texas.

These two patterns, together, were used on 49 percent of the 1989 winter wheat acreage, only slightly lower than the 52 percent accounted for by these patterns in 1988.

In the more moisture-abundant Corn Belt States (Illinois, Indiana, Ohio, and Missouri), corn and soybeans are important components of winter wheat rotations. The share of 1989 winter wheat acreage in corn-soybean-wheat rotations was the same as in 1988, although the individual States exhibited substantial variation. The share of acreage in soybean-soybean-wheat rotation, on the other hand, increased somewhat.

The barley-fallow-wheat rotation remained prevalent in Montana and to a lesser extent in Washington. Similarly the sorghum-fallow-wheat rotation was a common pattern in Kansas and Nebraska in both years. Idaho and California grew a variety of crops other than soybeans, corn, and wheat, such as dry beans and peas, barley, irish potatoes, and sugarbeets.

Spring Wheat

Land used for spring wheat production in 1989 showed a variety of cropping patterns (table C-3). Wheat-fallow-wheat was quite common in both 1988 and 1989. Montana, with 62 percent of its 1989 acres under this cropping practice, remained the leading State. In the other surveyed States, however, there were changes in the proportion of acres following this pattern. For all surveyed States combined, nearly 40 percent of the 1989 spring wheat crop was grown on land left idle in the preceding year, compared with 49 percent in 1988. In most of the surveyed States, 1989 spring wheat was preceded by barley on 5 to 10 percent of the acreage.

Where rainfall or irrigation permitted, more input-intensive crops were grown in the year preceding spring wheat production. In Idaho, 24 and 14 percent of the 1989 spring wheat acres were planted to potatoes and sugarbeets in the preceding year, similar to the 1988 pattern. In Minnesota, 32 percent of the spring wheat acres, in both 1989 and 1988, were planted to soybeans in the preceding years. Corn was grown on 16 percent of 1989 spring wheat acreage in the preceding year in South Dakota, 8 percentage points lower than in 1988.

North Dakota is the major State producing durum wheat, and 55 percent of the State's acreage planted to durum wheat in 1989 had been left fallow in the summer of 1988 (table C-3). This crop sequence reflects the moisture constraint farmers face in this area.

Soybeans

Cropping patterns in most soybean producing States were substantially the same in 1989 and 1988. The most common rotation practiced by farmers was soybean-corn-soybean. Forty-one percent of total soybean acres in both years followed this cropping pattern. Iowa, Illinois, Nebraska, Minnesota, Indiana, and Ohio used this rotation on 74, 60, 54, 53, 50, and 33 percent of their 1989 soybean acres (table C-4). This was very close to what farmers did on land producing soybeans in 1988. The rotation pattern was common because soybeans, in addition to competing economically with other crops, provide a natural source of nitrogen and a nonchemical means of controlling certain insects in the succeeding crops. Yields of corn and wheat crops planted after soybeans are, on average, 5-10 percent higher than those of corn and wheat crops planted after nonleguminous crops (2). Sorghum was another crop used on soybean acres in 1989 in Nebraska and Missouri. Its share was 14 and 8 percent in these States.

Another common practice was continuous soybean production. This practice was mostly used in the Southern States such as Arkansas, Louisiana, Mississippi, Missouri, and Tennessee in both 1989 and 1988. It appears to be a profitable practice in these States, although lack of program base acreage may have limited the diversity of cropping patterns on some farms. While soybeans in the South receive more herbicide treatment than in the North, very little insecticide is used on soybeans grown in the South.

In Georgia one of the common rotation practices was peanuts and soybeans. Fifteen percent of 1989 soybean acres grew peanuts the preceding year. The share was about the same in 1988. About 20 percent of soybean acres grew wheat the preceding year, and another 9 percent produced soybeans in both 1988 and 1989.

Table C-4--Cropping patterns used on land producing soybeans, 1989

Previous crop 1988	1987	AR	GA	IL	IN	IA	KY	LA	MN	MS	MO	NE	NC	OH	TN	Area	1988 Area
		Million acres planted															
		3.5	1.2	8.8	4.6	8.3	1.2	1.95	5.05	2.5	4.4	2.6	1.55	4.0	1.48	51.13	48.75
		Percent															
Soybean	Corn	nr	3	7	11	7	6	1	5	2	16	2	10	16	5	7	10
Soybean	Soybean	26	9	2	4	3	11	51	1	53	24	4	10	9	40	12	15
Soybean	Other	12	9	1	3	1	3	12	6	13	6	4	6	6	10	5	4
Corn	Corn	2	1	11	14	9	13	nr	6	1	5	13	6	8	5	8	8
Corn	Soybean	nr	8	60	50	74	24	nr	53	nr	22	54	23	33	13	41	41
Corn	Other	nr	6	10	8	4	10	1	5	nr	nr	4	11	11	10	6	4
Wheat	Soybean	18	5	3	1	nr	8	10	nr	4	5	nr	4	6	6	4	2/
Wheat	Other	5	15	2	1	nr	12	2	14	5	4	nr	7	5	3	5	4
Sorghum	Other	5	nr	nr	1	nr	1	2	nr	4	8	14	1	nr	1	2	2/
Rice	Soybean	17	nr	nr	nr	nr	nr	5	nr	5	1	nr	nr	nr	nr	2	2
Rice	Other	6	nr	nr	nr	nr	nr	5	nr	3	nr	nr	nr	nr	nr	1	nr
Fallow 1/	Other	5	8	3	5	2	9	2	4	2	4	2	11	1	2	4	5
Peanut	Other	1	15	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	*	2/
Sub-total		97	79	99	98	100	97	91	94	92	95	97	89	95	95	97	93
Other	Other	3	21	1	2	0	3	9	6	8	5	3	11	5	5	3	7
	Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

nr = None reported. * = less than 1 percent.

1/ Fallow includes land idled under farm commodity program provisions. 2/ Included in other.

Table C-5--Cropping patterns used on land producing rice, 1989

Previous crop 1988	1987	AR	CA	LA	Area	1988 Area
		Millon acres planted				
		1.15	0.42	0.52	2.08	2.13
		Percent				
Soybean	Soybean	33	nr	16	22	20
Soybean	Rice	28	nr	20	20	20
Soybean	Other	4	nr	4	4	4
Fallow 1/	Rice	3	3	4	3	11
Fallow	Fallow	2	1	13	5	6
Fallow	Other	2	2	4	3	4
Rice	Rice	5	81	9	21	18
Rice	Other	16	[illegible]	23	16	10
Sub-total		93	93	93	94	93
Other	Other	7	7	7	6	7
	Total	100	100	100	100	100

nr = None reported.

1/ Fallow includes land idled under farm commodity program provisions.

Table C-6--Cropping patterns used on land producing cotton, 1989

Previous crop 1988	1987	AZ	AR	CA	LA	MS	TX	Area	1988 Area
		Million acres planted							
		0.46	0.59	1.07	0.65	1.10	4.57	8.44	9.7
		Percent							
Sorghum	Other	nr	nr	nr	nr	nr	5	2	7
Soybean	Soybean	nr	11	nr	1	3	*	1	2
Soybean	Other	nr	5	nr	3	1	1	1	1
Cotton	Cotton	58	72	47	88	84	65	67	57
Cotton	Fallow 1/	[illegible]	nr	2	1	1	4	3	3
Cotton	Other	10	[illegible]	22	2	4	12	11	12
Sub-total		77	97	78	97	94	[illegible]	87	[illegible]
Other	Other	23	3	22	3	6	11	13	18
	Total	100	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent.

1/ Fallow includes land idled under farm commodity program provisions.

Cotton

Continuous cotton cropping was widely practiced in the six major cotton producing States in both 1988 and 1989 (table C-6). The share of acreage in continuous cotton increased in several States between 1988 and 1989. In Arizona, Arkansas, California, Louisiana, Mississippi, and Texas, continuous cotton was up 20, 8, 4, 10, 7, and 9 percentage points. Other crop rotation patterns were unchanged between 1988 and 1989. Despite increased weed pressure, continuous cotton remains the most economical cropping practice in these States (6).

Rice

There was little change in rice crop rotation practices between 1988 and 1989. The only change was observed in California, where continuous rice production, the most popular pattern, increased 9 percentage points (table C-5).

Conclusion

The comparison shows that while individual States vary their cropping patterns from year to year, overall crop production patterns for the two surveys indicate little change. Data for the major field crops produced during 1989 indicate that for most areas of the United States, farmers are already extensively utilizing crop rotation. However, for certain crops and States, continuous cropping is still widely practiced. Farmers in these areas of the country will likely examine and take advantage of the various crop rotation incentives provided by the 1990 farm bill.

References

1. Bezdicek, D. F., and D. Granatstein. "Crop Rotation Efficiencies and Biological Diversity in Farming Systems." *American Journal of Alternative Agriculture*, Vol. 4, Nos. 3 and 4, 1989, pp.111-117.

2. Metcalfe, D. S. and D. M. Elkins. *Crop Production: Principles and Practices.* Macmillan Publishing Co., Inc., 1980, Fourth Edition, pp. 451.

3. Olkowski, W. "Integrated Pest Management for Corn Rootworms and Cucumber Beetles". *IPM Practitioner*, Vol. 8, No. 1, 1986.

4. Pierce, F. J., and C.W. Rice. "Crop Rotation and Its Impact on Efficiency of Water and Nitrogen." In Hargrove, W.L. (ed.), *Cropping Strategies for Efficient Use of Water and Nitrogen*, American Society of Agronomy Special Publication 51, Madison, Wisconsin, 1988, pp. 21-42.

5. U.S. Dept. of Agriculture, Economic Research Service. "Low- input Practices," *Agricultural Outlook*, AO 148, December 1988.

6. U.S. Dept. of Agriculture, Economic Research Service. "Common Crop Rotations Among Major Field Crops," *Agricultural Resources: Situation and Outlook Report*, AR-15, August 1989.

Appendix table 1--U.S. fertilizer imports: Declared value of selected materials

Material	Fertilizer year 1988/89	Fertilizer year 1989/90	July-October 1989	July-October 1990
	$ million			
Nitrogen:				
Anhydrous ammonia	364	252	73	88
Aqua ammonia	na	4	2	#
Urea	252	201	52	68
Ammonium nitrate	38	43	12	14
Ammonium sulfate	24	29	7	5
Sodium nitrate	16	14	3	6
Calcium nitrate	11	10	2	2
Nitrogen solutions	50	28	5	6
Other	12	7	2	2
Total 1/	767	588	158	191
Phosphate:				
Ammonium phosphates	12	3	1	1
Crude phosphates	32	17	6	6
Phosphoric acid	#	#	#	#
Normal and triple superphosphate	#	#	#	#
Other	1	1	#	#
Total 1/	45	21	7	7
Potash:				
Potassium chloride	524	500	137	141
Potassium sulfate	15	9	2	3
Potassium nitrate 2/	15	15	3	3
Total 1/	554	524	142	147
Mixed fertilizers	19	34	11	7
Total 1/	1,385	1,168	318	352

na = Not available. # = Less than $500,000.

1/ Totals may not add due to rounding. 2/ Includes potassium sodium nitrate.

Source: (7).

Appendix table 2--Plant nutrient use by State for years ending June 30 1/

State/ region	1989 Nitrogen	1989 Phosphate	1989 Potash	1990 Nitrogen	1990 Phosphate	1990 Potash
	1,000 nutrient tons					
Maine	12	11	11	12	10	10
New Hampshire	3	1	2	4	2	3
Vermont	4	4	5	6	5	7
Massachusetts	9	4	5	13	5	7
Rhode Island	2	1	1	2	1	2
Connecticut	5	2	3	7	2	3
New York	77	61	91	92	68	94
New Jersey	27	14	19	29	16	20
Pennsylvania	71	53	56	74	53	58
Delaware	17	6	14	21	7	21
Maryland	85	31	25	44	27	36
NORTHEAST	313	188	232	306	198	261
Michigan	221	118	226	251	122	228
Wisconsin	230	125	314	236	125	307
Minnesota	561	235	312	647	261	406
LAKE STATES	1,011	477	852	1,134	508	941
Ohio	306	171	276	388	193	319
Indiana	447	218	358	584	252	430
Illinois	952	384	622	897	383	636
Iowa	934	304	465	947	328	500
Missouri	402	176	253	398	177	247
CORN BELT	3,041	1,254	1,974	3,215	1,334	2,132
North Dakota	209	138	26	278	148	27
South Dakota	196	86	20	169	84	22
Nebraska	722	146	37	725	156	39
Kansas	553	151	46	579	163	44
NORTHERN PLAINS	1,680	522	129	1,751	550	133
Virginia	79	55	75	91	63	90
West Virginia	[illegible]	8	8	9	9	9
North Carolina	198	99	182	219	105	192
Kentucky	179	104	128	192	109	132
Tennessee	148	94	112	156	96	116
APPALACHIA	613	361	506	667	381	538
South Carolina	77	34	69	82	36	68
Georgia 2/	207	107	156	210	115	164
Florida	246	98	261	248	104	256
Alabama	113	58	71	128	53	71
SOUTHEAST	643	297	558	670	308	559
Mississippi	165	47	63	208	66	94
Arkansas	243	60	84	258	62	85
Louisiana	152	47	65	176	48	61
DELTA STATES	560	154	212	643	177	240
Oklahoma	349	104	32	326	89	32
Texas	868	238	117	791	227	111
SOUTHERN PLAINS	1,217	342	149	1,117	315	143
Montana	93	66	12	97	71	14
Idaho	177	75	14	166	84	20
Wyoming	20	6	1	40	11	1
Colorado	181	49	18	171	55	21
New Mexico	36	13	6	44	12	5
Arizona	90	30	1	87	29	1
Utah	26	12	2	32	15	2
Nevada	4	3	0	4	2	0
MOUNTAIN	626	253	53	642	279	65
Washington	198	46	28	198	50	32
Oregon	143	40	26	147	44	33
California	554	174	83	554	184	95
PACIFIC	896	260	137	899	279	160
48 States and D.C.	10,600	4,109	4,802	11,043	4,330	5,172
Alaska	3	1	0	3	1	0
Hawaii	17	9	18	18	9	19
Puerto Rico	14	6	12	11	5	11
U.S. TOTAL	10,633	4,124	4,832	11,076	4,345	5,203

1/ Totals may not add due to rounding. 2/ 1990 data is estimated.

Source: (3).

Appendix table 3--Fertilizer use on corn for grain, 1990

State	Acres planted 1/	Fields in survey	Acres receiving: Any fertilizer	N	P205	K20	Application rates N	P205	K20	Proportion fertilized At or before seeding	After seeding	Both
	Thousand	No.	Percent				Pounds/acre			Percent		
Illinois	10,700	237	100	100	91	89	164	81	107	80	0	20
Indiana	5,600	294	100	100	96	89	139	75	111	49	0	50
Iowa	12,800	595	97	96	82	80	127	58	74	86	1	13
Michigan	2,400	70	99	96	90	94	123	52	95	52	0	48
Minnesota	6,700	181	98	98	90	86	113	51	69	86	1	12
Missouri	2,100	120	96	95	80	80	133	50	80	82	9	10
Nebraska	7,700	202	98	98	68	34	144	31	22 *	69	5	26
Non-irrigated	2,400	67	94	94	48	30	96	31	22 **	76	13	11
Irrigated	5,300	135	99	99	78	36	164	32	22 *	66	1	33
Ohio	3,700	156	99	99	94	89	151	72	101	48	1	51
South Dakota	3,400	113	77	77	58	33	80	42 *	24 *	79	9	11
Wisconsin	3,700	118	100	100	96	95	79	52	74	75	2	23
Area	58,800	2,086	97	97	85	77	132	60	84	74	2	24

* = CV greater than 10 percent.

1/ Preliminary.

Appendix table 4--Fertilizer use on cotton, 1990

State	Acres planted 1/	Fields in survey	Acres receiving: Any fertilizer	N	P205	K20	Application rates N	P205	K20	Proportion fertilized At or before seeding	After seeding	Both
	Thousand	No.	Percent				Pounds/acre			Percent		
Arizona	340	79	94	94	47	8	155	60 *	21 **	11	59	30
Arkansas	760	95	100	99	83	87	85	36	57	28	4	67
California	1,050	213	94	94	31	3	140	68	40 **	45	22	32
Louisiana	780	85	99	99	62	62	77	48	62	43	33	24
Mississippi	1,200	163	99	99	42	56	109	50	78	20	21	59
Texas	5,600	516	67	66	48	20	59	40	17 *	69	14	17
Area	9,730	1,151	80	79	49	31	86	44	47	49	19	32

* = CV greater than 10 percent. ** = CV greater than 20 percent.

1/ Preliminary.

Appendix table 5--Fertilizer use on rice, 1990

State	Acres planted 1/	Fields in survey	Acres receiving: Any fertilizer	N	P205	K20	Application rates N	P205	K20	Proportion fertilized At or before seeding	After seeding	Both
	Thousand	No.	Percent				Pounds/acre			Percent		
Arkansas	1,230	234	98	97	15	18	114	47	57	10	62	28
Louisiana	570	154	99	99	81	79	115	45	45	5	58	37
Area	1,800	388	98	97	36	37	114	45	49	9	61	31

1/ Preliminary.

Appendix table 6--Fertilizer use on soybeans, 1990

State	Acres planted 1/	Fields in survey	Acres receiving: Any fertilizer	N	P205	K20	Application rates: N	P205	K20	Proportion fertilized: At or before seeding	After seeding	Both
	Thousand	No.	---------Percent--------				-----Pounds/acre----			------Percent-------		
Northern:												
Illinois	9,200	176	37	16	27	34	25 **	[illegible]	96	95	3	2
Indiana	4,300	253	45	22	33	44	16 **	41	90	97	1	2
Iowa	8,000	587	15	10	11	14	34 **	40	56	91	9	0
Minnesota	4,600	106	13	12	12	13	16 **	34 *	62 **	93	0	7
Missouri	4,200	143	15	8	14	15	21 **	41	63	100	0	0
Nebraska	2,400	[illegible]	17	15	12	5	32 **	40 *	32 **	93	7	0
Ohio	3,700	113	47	20	29	47	11 **	48 *	105	96	2	2
Sub-area	36,400	1,464	27	14	20	25	22 *	47	87	95	3	2
Southern:												
Arkansas	3,100	137	28	13	24	26	38 **	53 *	67	89	11	0
Georgia	900	95	73	58	72	73	19	40	69	97	1	1
Kentucky	1,250	133	53	36	49	46	40 *	72	84	97	3	0
Louisiana	1,800	108	31	15	30	27	23 **	45	55	94	6	0
Mississippi	2,100	108	25	13	19	23	43 **	39	67 *	93	0	7
North Carolina	1,400	137	66	50	61	66	16 *	40	[illegible]	97	2	1
Tennessee	1,300	131	51	35	50	51	30 *	42	56	93	7	0
Sub-area	11,850	849	41	26	38	39	28	47	70	94	5	1
Area	48,250	2,313	31	17	24	29	24	47	81	95	3	1

* = CV greater than 10 percent. ** = CV greater than 20 percent.

1/ Preliminary.

Appendix table 7--Fertilizer use on wheat, 1990

State	Acres 1/ 2/	Fields in survey	Acres receiving: Any fertilizer	N	P205	K20	Application rates: N	P205	K20	Proportion fertilized: At or before seeding	After seeding	Both
	Thousand	No.	---------Percent--------				-----Pounds/acre-----			------Percent-------		
Winter wheat:												
Arkansas	1,300	67	100	100	31	31	100	41	55	8	62	30
Colorado	2,550	86	65	64	18	nr	41	22 *	nr	80	13	7
Illinois	1,950	66	100	100	90	79	85	74	91	16	9	75
Kansas	11,800	242	[illegible]	[illegible]	44	9	49	29	21 *	63	10	27
Missouri	2,000	72	96	96	78	[illegible]	84	51	71	32	17	51
Montana	2,600	94	76	76	67	18	47	28	17 **	77	6	17
Nebraska	2,250	84	79	79	22	#	50	27 *	#	74	16	9
Ohio	1,350	72	99	97	95	90	75	66	70	17	5	78
Oklahoma	6,300	157	91	91	62	10	65	34	25 *	58	4	38
South Dakota	1,700	72	41	41	26	[illegible]	35 *	24	#	51	35	15
Texas	4,200	162	66	66	35	5	88	37	10 **	66	13	21
Washington	2,200	105	98	98	33	[illegible]	65	19	#	87	3	11
Area	40,200	1,279	84	84	48	18	62	38	57	57	12	31
Spring wheat:												
Minnesota	2,800	71	97	97	87	70	83	42	34 *	97	1	1
Montana	2,800	64	52	52	52	9	39 *	30	7 *	100	0	0
North Dakota	8,000	107	69	69	62	20	44	31 *	12 *	99	1	0
South Dakota	2,200	52	58	58	44	6	40 *	29	8 *	93	3	3
Area	15,800	294	69	69	62	25	53	33	23 *	[illegible]	1	1
Durum wheat:												
North Dakota	3,100	130	61	59	57	7	35	25	8 *	100	0	0
All wheat 3/												
Arkansas	1,300	67	100	100	31	31	100	41	55	8	62	30
Colorado	2,550	86	65	64	18	nr	41	22 *	nr	80	13	7
Illinois	1,950	66	100	100	90	79	85	74	91	16	9	75
Kansas	11,800	242	89	88	44	9	49	29	21 *	63	10	27
Minnesota	2,800	71	97	97	87	70	83	42	34 *	97	1	2
Missouri	2,000	72	96	96	78	83	84	51	71	32	17	51
Montana	5,400	158	63	63	59	14	44	29	14 **	87	4	10
Nebraska	2,250	84	79	79	22	nr	50	27 *	nr	74	16	10
North Dakota	11,100	237	67	66	60	16	42	30 *	12 *	99	1	0
Ohio	1,350	72	99	97	95	90	75	66	70	17	5	78
Oklahoma	6,300	157	91	91	62	10	65	34	25	[illegible]	4	38
South Dakota	3,900	124	51	51	36	5	39	27	7 *	78	15	7
Texas	4,200	162	66	66	35	5	88	37	10 **	66	13	21
Washington	2,200	105	98	98	33	[illegible]	65	19	#	[illegible]	3	15
Area	59,100	1,703	79	79	52	19	59	36	44	69	9	22

* = CV greater than 10 percent. ** = CV greater than 20 percent.
# = Insufficient data. nr = None reported.

1/ Acres are harvested for winter wheat and planted for all other crops. 2/ Preliminary. 3/ Does not include winter wheat in Mn, and ND; spring wheat in CO, and WA; or durum wheat in MN, MT, and SD.

Appendix table 8--Projected world supply-demand balances of plant nutrients for years ending June 30

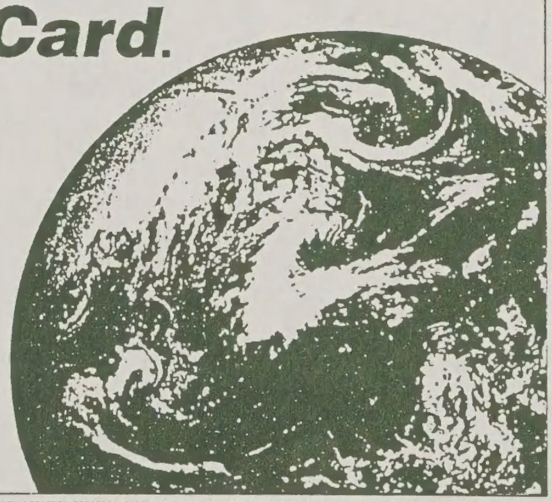
World regions	Nitrogen 1990	Nitrogen 1995	Phosphate 1990	Phosphate 1995	Potash 1990	Potash 1995
			Million metric tons			
Developed market economies:						
Supply	21.57	22.14	17.70	17.66	16.98	16.84
Demand	23.98	23.48	11.92	11.71	11.51	11.59
Balance	-2.41	-1.34	5.78	5.95	5.47	5.25
North America--						
Supply	11.08	11.94	9.87	10.15	10.46	10.35
Demand	11.60	11.50	4.60	4.40	5.10	5.16
Balance	-0.52	0.44	5.27	5.75	5.36	5.19
Western Europe--						
Supply	9.20	9.02	5.10	4.73	5.29	5.18
Demand	10.81	10.20	5.05	4.88	5.45	5.40
Balance	-1.61	-1.18	0.05	-0.16	-0.16	-0.22
Oceania--						
Supply	0.39	0.38	1.09	1.15	0.00	0.00
Demand	0.48	0.62	1.25	1.35	0.24	0.27
Balance	-0.09	-0.24	-0.16	-0.20	-0.24	-0.27
Other countries--						
Supply	0.90	0.80	1.64	1.63	1.23	1.31
Demand	1.09	1.16	1.02	1.08	0.72	0.76
Balance	-0.19	-0.36	0.62	0.55	0.51	0.55
Developing market economies:						
Supply	20.80	25.84	9.60	11.10	0.87	0.84
Demand	21.03	26.14	10.00	12.30	4.90	6.09
Balance	-0.23	-0.30	-0.40	-1.20	-4.03	-5.25
Africa--						
Supply	0.57	0.68	4.11	4.98	0.00	0.00
Demand	0.79	1.05	0.65	0.92	0.29	0.39
Balance	-0.22	-0.37	3.46	4.06	-0.29	-0.39
Latin America--						
Supply	4.68	5.06	1.92	2.00	0.07	0.00
Demand	3.90	4.50	2.60	3.10	2.15	2.60
Balance	0.78	0.56	-0.68	-1.10	-2.08	-2.60
Near East--						
Supply	4.99	6.62	1.45	1.82	0.79	0.84
Demand	3.34	4.16	1.84	2.38	0.18	0.23
Balance	1.65	2.46	-0.39	-0.56	0.61	0.61
Far East--						
Supply	10.56	13.48	2.11	2.30	0.00	0.00
Demand	13.00	16.43	4.91	5.90	2.28	2.87
Balance	-2.44	-2.95	-2.80	-3.60	-2.28	-2.87
Centrally planned countries of Asia:						
Supply	15.24	16.46	3.34	3.88	0.06	0.08
Demand	20.10	22.10	5.59	6.45	1.65	2.20
Balance	-4.86	-5.64	-2.25	-2.57	-1.59	-2.12
Eastern Europe and the USSR:						
Supply	24.22	24.70	9.84	9.83	12.46	12.19
Demand	15.60	15.60	10.50	10.00	9.00	7.50
Balance	8.62	9.10	-0.66	-0.17	3.46	4.69
WORLD TOTAL:						
Supply	81.82	89.15	40.48	42.47	30.36	29.95
Demand	80.71	87.32	38.01	40.46	27.06	27.38
Balance	1.11	1.83	2.47	2.01	3.30	2.57

Source: (4).

List of Tables

Appendix tables

Special articles



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